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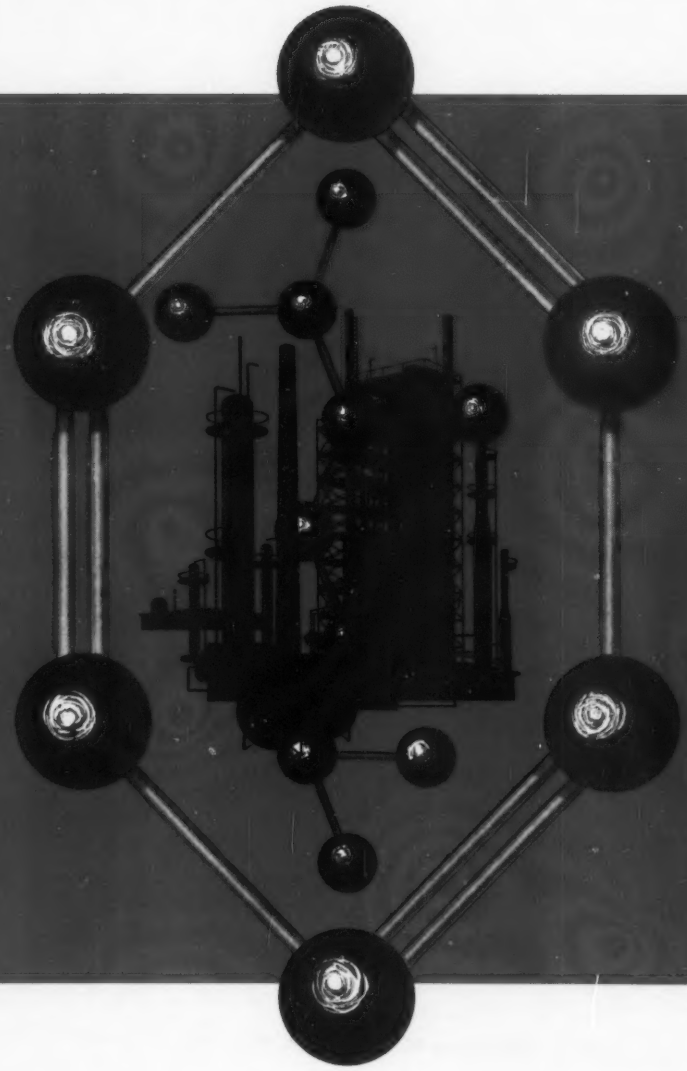

THE 1961 PETROCHEMICAL HANDBOOK ISSUE

102 PROCESSES SHOWING FLOW DIAGRAMS

PAGE 199

Plus...

Hydrocarbon Oxidation Today 309
16 Steps to Better Safety 331

NOVEMBER 1961

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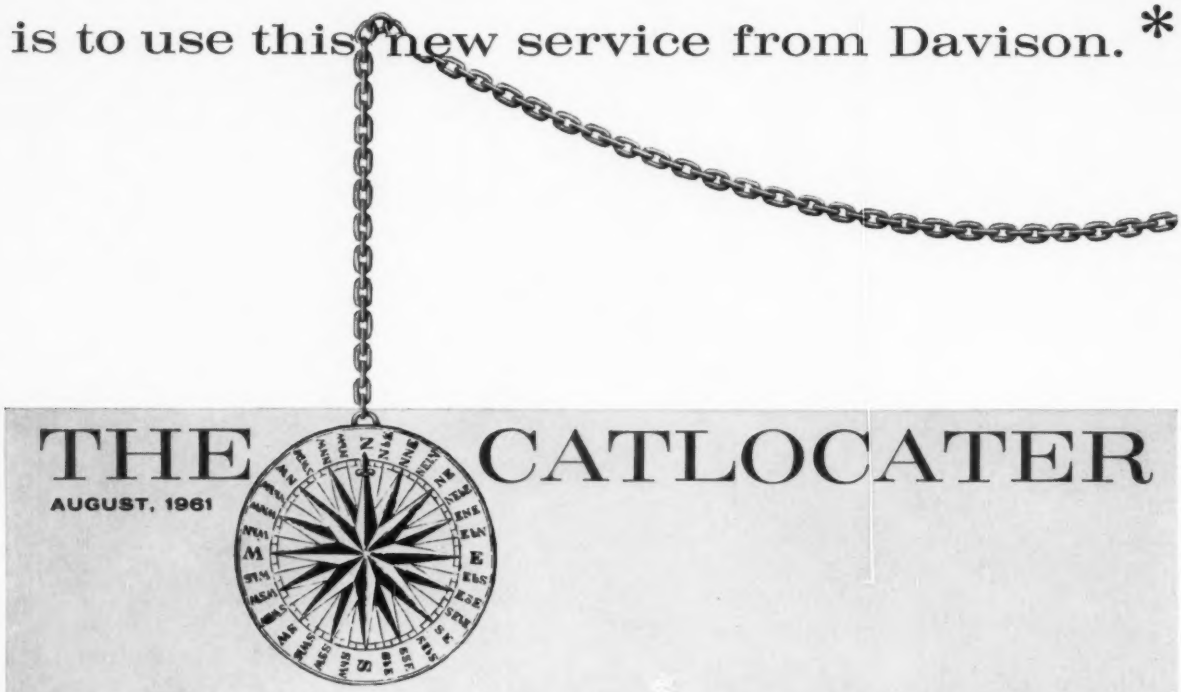

THE CATLOCATER

AUGUST, 1961

As a part of our continuing customer service program, Davison provides this bi-weekly availability bulletin on Equilibrium Fluid Cracking Catalysts. The sources listed herein and quantities available are constantly subject to change so that these figures are approximations only, based on the latest information available at the time of this mailing.

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HYDROCARBON PROCESSING & Petroleum REFINER

VOL. 40, NO. 11, NOVEMBER 1961

Departments

Advertisers 471
Books 404
Classified 470
Construction 348
Editorials 13
Equipment 427
How to Do It 338
Letters 197
Meetings 385
Men 386
News ..... 9 & 39
Readers' Service 473
Suppliers 406

Petrochemical Handbook

199 Title

201 Foreword

203 Index to Process Section

204 Index to Contributors

309 Combine O_2 & Hydrocarbons for Profit (Part 1) *Marshall Sittig*

As Management Sees It

321 Management Development (Part 2) *Charles H. Vervalin*

326 Judging People by Psychology (Part 2) *Dr. Richard I. Evans*

331 16 Steps to a Sound Safety Program *Charles Homewood*

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A Quick Look at This Issue

☐ **Petrochemical Handbook (1961) . . .** Here you'll find 102 processes—many of the regular ones and some brand new, first-time-anywhere processes. In the regular category are: Six different processes for acetylene, five for ammonia, Bisphenol A, butadiene from butenes and butane, carbon black, three for ethylene, a couple for ethylene oxide, three for methanol, and six for urea. And, be sure to check the new ones: Acetaldehyde from ethylene, isoprene from propylene, polycarbonates, polyethylene (AGFO), isotactic polypropylene, terephthalic acid from benzene, trimethylolpropane, vinyl acetate, maleic anhydride from butenes, and several others. Descriptions accompanying the flowsheets give enough information for quick comparison. Many contributors will welcome inquiries for more details. Rather than tear out these hundred pages, save the entire issue for further reference. For the data-packed Petrochemical Handbook, turn now to **Page 201.**

☐ **Combine O_2 & Hydrocarbons for Profit (Part 1) . . .** Begin now to read this first part of a 12-part series which kicks off with fundamentals of oxygenation chemistry with background information on thermodynamics, stoichiometry, kinetics and catalysts for oxidation of hydrocarbons. See **Page 309.**

☐ **Management Development: Part II . . .** Are the methods used in training today's managers and potential managers satisfactory—or is organized supervisory training plagued with fads and hit-and-miss programs? You'll get an interesting insight into the "big picture" of present trends in management development by turning to **Page 321.**

☐ **Judging People by Psychology: Part II . . .** Industry's problems with human relations and communications show we all have a great deal to learn about dealing with people. One of the troublesome areas—but one seldom discussed at the business level—is a problem the psychologist calls "stereotyping." The stereotyping problem can cloud human relations in your business life. For an interesting analysis of this problem, see **Page 326.**

☐ **16 Steps to a Sound Safety Program . . .** How long has it been since you took a close look at your company's safety program? The author of this article did—and some of the problem areas he covers may exist in your plant. Here's your chance to crystallize your company's safety shortcomings—plus some tips on what you can do about it. See **Page 331.**

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Impact a result of contact: Public Speaking not an end, but a vital means to an end

There certainly is no better tool in developing executive or management qualifications than through public speaking. Spoken words are a powerful tool of business. They are used to organize, motivate, coordinate, control, and train.

Since an executive must achieve results through people, he must be able to plan and organize. As a leader, he must be able to motivate and inspire people to action; he must make himself understood. He must have purpose and the will to make other people aid that purpose.

A speaker, too, achieves his results through people. He, too, must be able to plan and organize; must lead; must be able to motivate and inspire others to action; must make himself understood. The speaker must have a purpose and the will to make others aid that purpose. The skills of the executive are identical with those of a speaker, in these areas.

It is not surprising, then, that aspiring leaders in business and industry are judged by their associates and superiors, to a great extent, by their abilities to communicate. It is not surprising that an executive can sell himself, can attain greater authority by broadening his capacities for directing and leading, through oral communication.

Words have great power, particularly the spoken word. Words give you contact with other men, and if you use them effectively, they give you — *impact*. That impact is multiplied as you develop your ability to speak, and as you speak to more important audiences.

If you are a novice in public speaking you are not alone. No more than 25 per cent of our speakers could qualify as "veterans."

Like conversation, speaking before an audience is based on sincerity and belief. It involves conviction and concern. The public speaker is most convincing when he is least artful, when he is most natural, and above all, when he is sincere.

Effective speaking is not an accident. It is not the special endowment of a few. While talking before many listeners may come naturally for a few, it is, by and large, a learned art. It consists of an idea, phrased simply, and delivered with conviction and with an expressive voice.

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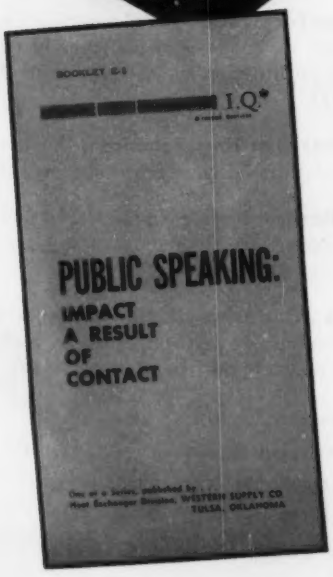

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A Pair of Offers

NOT LONG AFTER you receive this, your regular subscription copy of the November Petrochemical Handbook issue, there will be available separates of the 110-page Petrochemical section. We are calling this to your attention not because we think you might need a duplicate copy of this compendium of flowsheets and process descriptions but rather to put you in position of being able to tip off individuals in a borrowing mood that may be showing up about that time. You can—and we hope you will remember to—tell them that for one buck sent to HYDROCARBON PROCESSING & PETROLEUM REFINER, Box 2608, Houston 1, Texas, they can get their own copy. A better bargain still is for them to send $3.00 for a full year's subscription which, if requested, will bring with it as a bonus one of these Petrochemical reprints. Incidentally, such a plan would give them, before the year is out, the 1962 Process Handbook Issue which we've already got simmering and which will be ready to serve next September.

They Know Where!

YOU MIGHT TERM IT "metamorphosis," but whether you like that fo' bit word or not, the petrochemical maintenance people now know where they can get authentic, helpful data—and regularly.

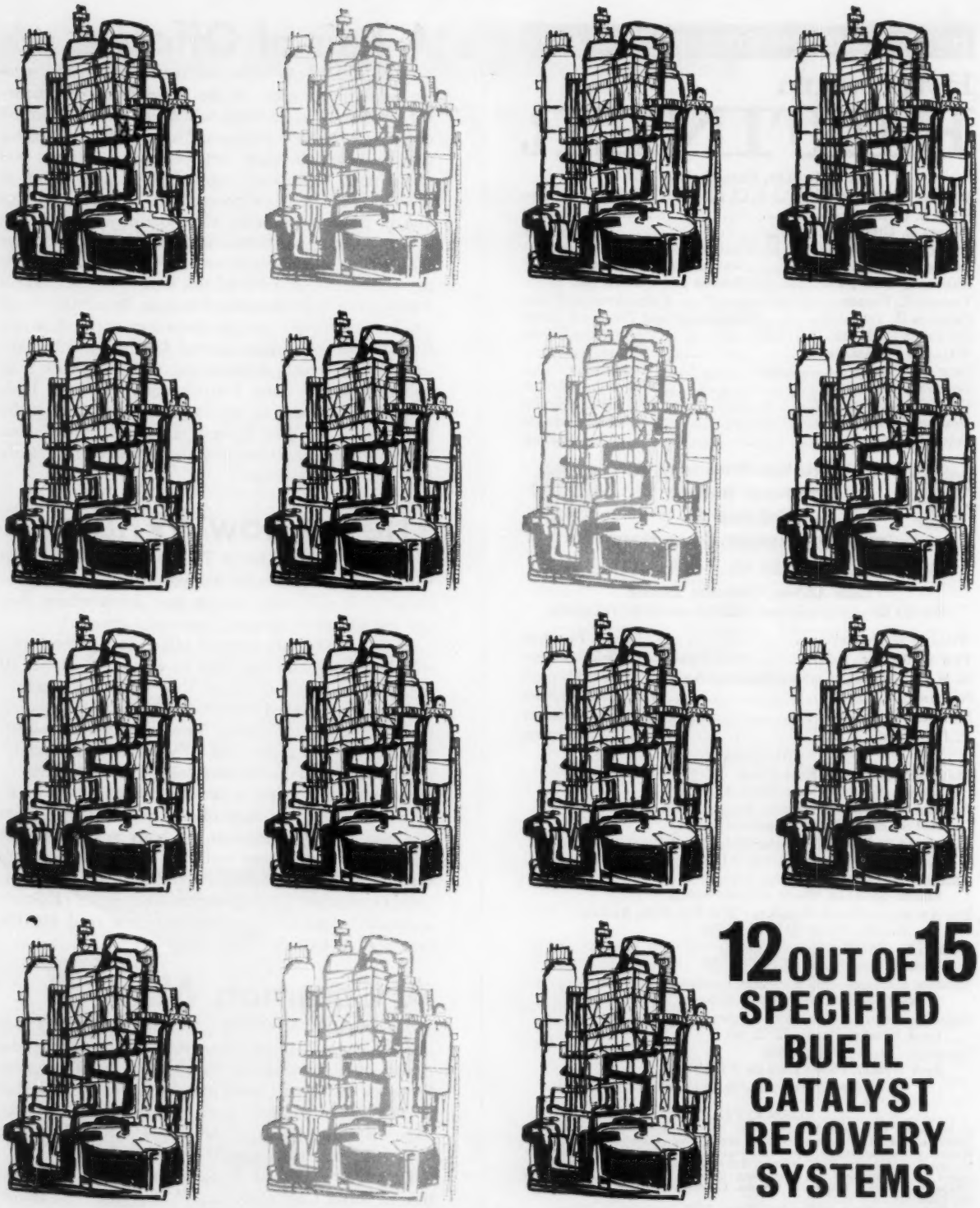
One of our editors recently talked to a petrochemical plant man who said that he was a PR reader 10 or 12 years ago but found that most maintenance articles were directed more toward petroleum refining than petrochemical plants. Two years ago he started reading HP-PR again and "I've noticed a marked improvement in petrochemical plant maintenance coverage." He asked why the "startling change" whereupon the workings of our engineering editors and the ascending interest in both petrochemicals and maintenance were outlined to him. "Keep up the good work," he admonished. "Most of the maintenance engineering staff at the XYZ plant (Editor's comment: And it's a major one) now read HP-PR on a regular basis."

A Common Mark

SELDOM A MONTH passes that you don't find in this Page 7 space some reference to what the reader of HYDROCARBON PROCESSING & PETROLEUM REFINER can expect next month. If any explanation of this rather routine practice appears called for, then we suppose it's just because HP-PR dishes out something real tasty month in and month out. So—

December's Special Report carries the intriguing title of "The Cost of Octanes" and will be a handbook on how to make high quality gasoline for the least cost. If there's a single mark common to all HP-PR subscribers, it's the well known dollar mark; so when we publish articles relating to cost, then we know there's a huge and deeply interested reception committee awaiting arrival of the issue.

Final fact: Five sections make up the review—reforming, antiknocks, alkylation, isomerization and that newcomer, hydrocracking.



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From the editors ...

Quick Look at HPI

CANADIAN OIL IMPORTS INTO U.S. in news as Interior Department seeks to "stabilize" rapidly rising amount of crude coming into this country from Canada. Current Canadian imports have gone over 200,000-bpd mark. Says Interior Secretary Udall: "We have been discussing gradualism with them and hope we can reach an agreement soon."

GERMAN COAL FIRM HITS "REFINING TRAIL" as government-owned Saarbergwerke announces plans to build refinery because it fears refineries in Southern Germany will hurt coal sales there. Firm wouldn't be only German coal firm to go into oil. Scholven Chemie which operates 46,000-bpd refinery is owned by coal company, as is Gelsenberg Benzin and Deutsche Erdoel.

NO SMOG CAUSED BY MOTOR FUEL ADDITIVES says study cited by Los Angeles Air Pollution Control District. Testifying at California Assembly hearings on fuel composition and its relation to smog were representatives of WOGA, State Department of Public Health, Citizens Anti-Smog Committee, Ethyl Corp., and APCD.

FOREIGN INVESTMENT IN U.S. PETROLEUM INDUSTRY has book value of $1.2 billion according to new Commerce Department report. Figure has tripled since 1950, mainly because of undistributed profits. United Kingdom alone has $300-million slice, while Canada has $200 million invested. Data came from survey of direct foreign investments in U.S. firms in which at least 25% controlling interest is held abroad.

OIL-COMPANY IMMUNITY FROM ANTI-TRUST has been extended to oil firms participating in reorganized Military Petroleum Advisory Board, when information they give MPAB could result in litigation. Interior Secretary Kelly says move will enable companies to "participate more fully in essential mobilization studies." Plan had birth in 1955 to help insure adequate oil supplies during Suez crisis. It will now be amended to include any mobilization by oil companies during present international crisis.

SPECIAL ASTM SYMPOSIUM reports capillary gas chromatographs and flame ionization detectors are useful in quantitative analysis of many petroleum products. Aviation gasoline, for example, can be more precisely analyzed by the gas chromatograph than by other techniques . . . Other ASTM developments: New reference fuels to be proposed next year for cetane engine test method. The fuels: A purer n-cetane and heptamethyl-nonane. Latter will take place of present low-cetane-number alphamethylnaphthalene . . . Work has been started on new engine test methods to predict knock characteristics of motor gasoline. Goal: Engine test methods with more significance and precision than present Motor and Research techniques. Study will center on better equipment and instruments, fundamentals of knock testing, and road test data.

PANNING THE PROCESS AND PRODUCT SCENE you'll see Olin Mathieson up with new process to make glycerol in plant planned for Brandenburg, Ky. Propylene oxide will be converted to allyl alcohol over new company-

developed catalyst. Alcohol then goes to glycerol . . . Union Carbide develops general-purpose epoxy plasticizer which offers "superior heat and light stabilization, excellent low-temperature flexibility, improved compatibility in vinyl plastics" . . . Standard of Ohio says it has developed "world's first four-grade motor oil which meets all automobile manufacturers' requirements under all driving conditions" . . . New frozen-earth process for storing liquid gases underground at -250° F has been developed by Conch International Methane and Constock Pritchard Liquifaction. Ground is frozen around area to be excavated, vapor sealed roof goes over hole—then pit is filled.

Polymers being made from normally non-polymerizing monomers via gamma radiation under high pressure. Method, developed by National Bureau of Standards, opens new doors to understanding of radiation and polymerization kinetics. Mechanisms could be basis of new sources of polymers.

MERGERS, JOINT ENTERPRISES IN NEWS as Air Products buys Sun Oil's 160,000 shares of Houdry stock, and offers to buy remaining shares from other stockholders. Goal: Merger of Houdry into Air Products, former to be operated as separate division . . . Cities Service moves into chemical in European Common Market via purchase of big chunk of Belgium's Ammoniaque Synthetique et Derives. Company is considering other cooperative enterprises in ECM . . . Rumianca S.p.A., Italian chemical firm, and Pittsburgh Plate Glass International form Chimica Sarda S.p.A. to make glycerine, trichlorethylene, perchlorethylene and ethylene dichloride . . . Monsanto sets up new Hydrocarbons Division combining petroleum and petroleum-based chemical operations. It includes Alvin, Texas, and Texas City plants plus Lion Oil subsidiary, which will continue to operate under Lion brand.

QUICK LOOK AROUND THE WORLD finds Montecatini licensing its polypropylene plastic and fiber process to six Japanese companies. Mitsubishi Petrochemical, Mitsui Chemical and Sumitomo Chemical will make "isotactic" polypropylene, while Mitsubishi Rayon, Toyo Rayon and Toyo Spinning will produce fibers . . . Standard of Indiana considering refining stake in Japan, possibly through purchase of interest in Kyushu Oil, which plans 40,000-bpd refinery at Tsurugasaki . . . Gulf Oil's 273,000-bpd Port Arthur refinery shut down temporarily by strike of 180 machinists—followed by OCAW refusal to cross IAM picket lines. Plant went back on stream when mutual OCAW-IAM agreement sent non-machinists back to work.

Cuba facing severe refining problems with Russian equipment and supplies. U.S.S.R. isn't meeting delivery dates for expansion equipment, and what is getting through isn't up to par. Another Cuban headache: Refineries won't operate well on Russian crudes with exception of former Texaco plant . . . Japan looms as big LPG importer with government announcement that present 500,000-ton-per-year level will hit 1.9 million by 1970. But government has asked Japanese oil industry to cut capital investment 8.4% beginning with reduction of planned $310.5 million in Fiscal 1961 to $284.5 million.

FOR MORE NEWS AND TRENDS on the HPI's latest developments in technology, economics, government affairs, and general-interest news, don't miss "What's Happening" beginning on page 39.

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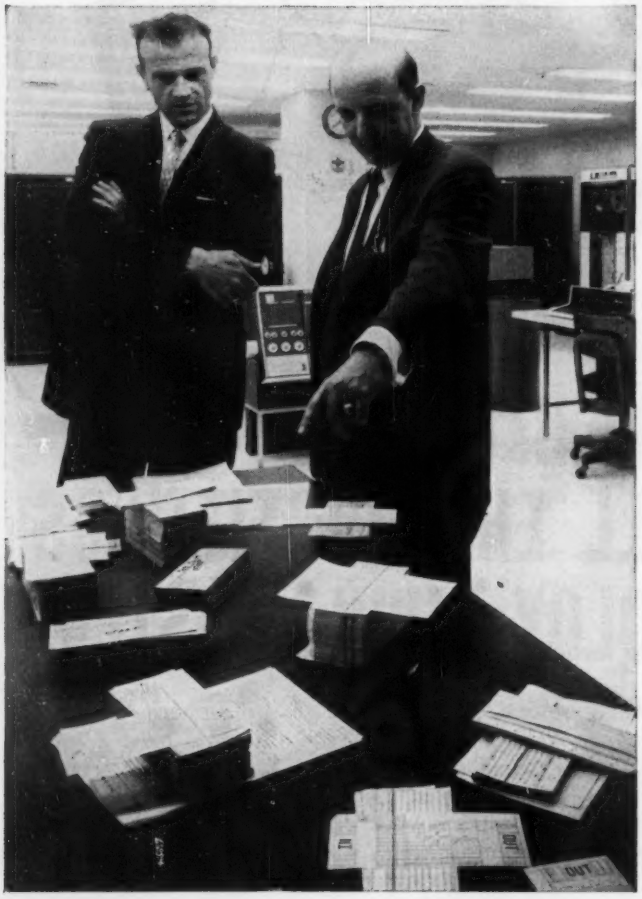
1 Many of the computer programs in Kellogg's extensive library have been developed jointly by process engineering and computer specialists.

More efficient engineering and sounder new plant investments will result from use of a new high-speed IBM 7070 computer installed at The M. W. Kellogg Company's headquarters in New York.

The new computer and improved programming techniques mark another major stride in Kellogg's continuing improvement of its engineering services. Its speed makes practical rigorous calculation and the evaluation of multiple solutions to difficult design problems—a vital step in achieving the most economic design.

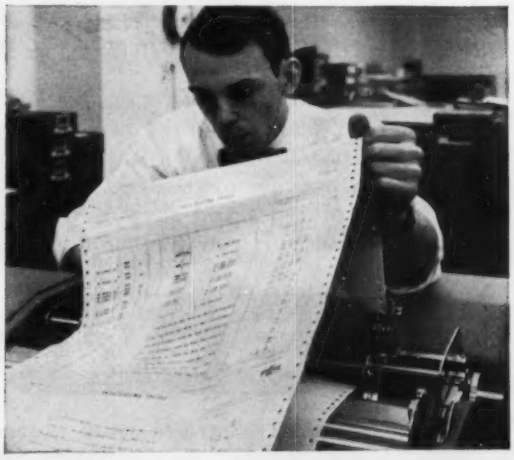
The computer's large capacity will enable Kellogg to develop new methods which can be applied to plant engineering problems. In addition, it will permit Kellogg to broaden its present activities in such areas as computer control, process dynamics, and systems engineering.

New engineering techniques and increased engineering efficiency are vital to the creation of optimum plants. If you are planning a new plant, Kellogg engineering services, more than ever, can help you achieve optimum plant design and a more economic investment.



2 Engineering data and computer commands, punched on cards and stored on magnetic tape, are read into the computer.

3 A printout provides engineering data ready for evaluation. Simplified methods permit ready use of computer for solving a wide range of process and mechanical design problems.



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"Safety Is Boring!"

"SAFETY BORES ME!" If ever there was a statement that summarizes the feelings among many engineering-operating people in the HPI, this is it. And let's at least be honest with each other. Safety *is* a boring subject.

If this isn't so, it's hard to justify the endless bombardment of safety courses, posters, contests, pamphlets, campaigns, and other approaches safety people use to keep us aware of this "boring" subject—so easy to otherwise ignore. Safety personnel wage a constant battle to submerge the feeling that safety is uninteresting, dry, pessimistic and crammed with drab statistics.

Why should a subject so often a matter of life and death or serious injury be boring? Maybe it's because people have a curious way of ignoring things closest to them until something drastic happens. We've all met the "foxhole Christian" who, when the dangers and tribulations of life seem overwhelming, says "Oh Lord, if you'll just get me out of this I'll . . ." Then, most of us have met the guy who ran around on his sweet, gracious, understanding wife until he slipped up and landed in the divorce court. "My God, if only I had stopped long enough to see how lucky I was to have her. . ."

Indifference. Safety consciousness (or lack of it) follows this same pattern. Sometimes it takes a fatal accident or near disaster to make us "see the light." The National Safety Council's annual convention in Chicago last month, attended by one of our editors, hammered away again, as it has in the past, at the "human factor" in safety. The thesis is one we've heard over and over and over from the safety people in the HPI. It could be stated something like this: No matter how many mechanical precautions you take, no matter how many contests, and other gimmicks you use to promote safety awareness, they're all worthless without the cooperation of *every* man on the line.

This has been proven many times. The statistical analyses, psychological studies, and other approaches Safety Departments use to prove the "human factor" point would probably fill Yankee Stadium. Yet, accidents go on happening. Sure, there are far fewer accidents in the HPI now than only a few years ago. But let's not lull ourselves into apathy with this kind of rationalization.

The fact remains, those men that died this year in explosions at Phillips' Borger, Texas, plant, Ethyl's Baton Rouge plant, and Signal's Houston refinery, are just as dead as they would be if the accidents they were involved in were the only ones in the entire HPI.

This is not to disparage these fine companies, their safety practices or their personnel. There have been similar tragedies elsewhere this year, and they could have just as likely occurred at Gulf, Shell or any one of the dozens of HPI companies. But their fate was to be among the unfortunate examples of what *could* happen any time, anywhere, in any processing plant.

A cause for everything. The important thing is that nothing happens without a cause. Beginning with Genesis and the first cause—"In the beginning God *created*. . ."—life is a matter of cause and effect. Thus, in a very real sense, there is no such thing as an *accident*.

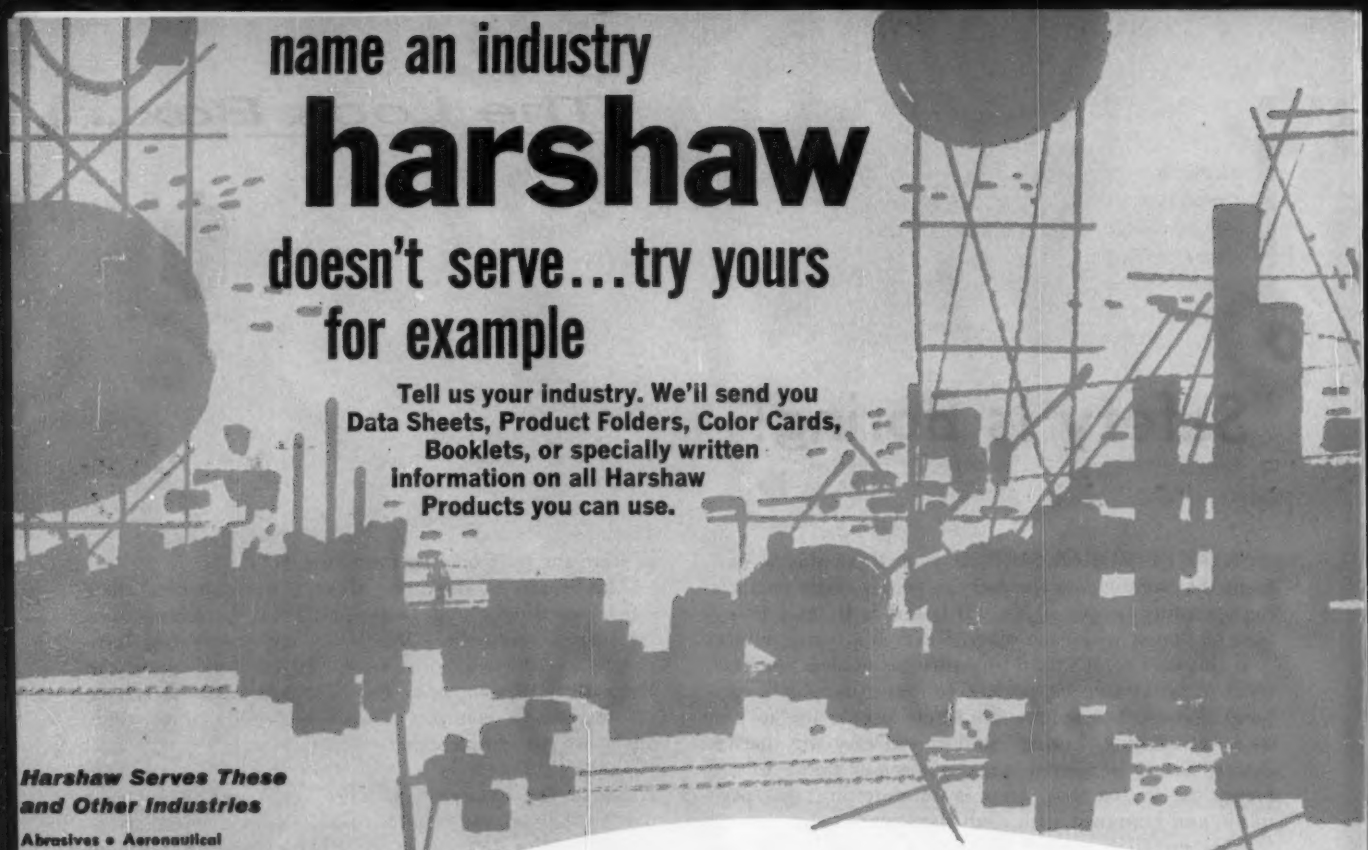
This word has come to imply something fatalistic—beyond the reach of man's ability to intervene. A motorist glances from the road momentarily and dents your fender. "Gee, I'm sorry mister. It was just an *accident*." Corrosion is neglected in a unit's piping and there is an explosion. "Gosh Bill, it was too bad about that *accident* yesterday over at #4 still." Accidents are *caused*. The catalyst is human neglect or oversight.

Working in the HPI plant is one of the most dangerous occupations in the world, bar none, and we had better not forget it for even five minutes. It's far too easy to pat ourselves on the back and talk about how many millions of continuous non-injury manhours we've chalked up unit so-and-so. The spirits of those guys who died at Borger, Baton Rouge and Houston are still there to haunt us.

Whose responsibility. Safety is everybody's responsibility. Sound trite? Maybe so, but those who have died in HPI accidents could vouch for it if they were here. Ask their surviving wives and kids. You know the answer they'll give.

In a sense, safety is a big jigsaw puzzle. Leave a part out and the picture is incomplete. As far as the HPI is concerned, it begins on the drawing board in the design department. There aren't many goof-ups here—*but they have happened* and could happen again. The pieces of our picture continue to fall into place as the plant is constructed, with all its attending dangers. Then there is the startup. As an HPI engineer you know how many fires and explosions have occurred in this phase of bringing a new unit on stream.

We move on into operations. Visualize a 100,000-bpd



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refinery running 24 hours a day. Tons and tons of highly flammable, volatile materials under the direct supervision of *people*. One careless moment, and WHAM! Then, of course, there's turnaround, with the hygiene problems of "hot work" inside the big vessels, replacing worn and dangerous valves, etc. *People* are doing the work. Next time you're out in the plant, standing under tons of piping and valves, ask yourself if the pipefitters, operators, electricians, etc., have had the feeling safety is "boring."

A mental 'Albatross.' The examples that could be used to point up this lack of safety-awareness could reach into infinity—adding to that pile in "Yankee Stadium." But let's not waste any more paper on this "dry subject." We can wrap it up by recalling the seaman in "Rhyme of the Ancient Mariner." He wore a dead Albatross bird around his neck as a reminder of the blunder of killing this feathered good-luck symbol of the sea. We can't wear an Albatross around our necks (or a safety poster). But we can plant a sign in the mind that reads "Danger—Human Factors at Work."

Human factor? You bet there is a human factor. The problem is that too many of us have been too long in realizing that the best kind of safety motivation is *self motivation*. The grandest safety program in all the world is worthless when we can too easily shrug our shoulders and say, "safety is boring."

Yes, safety is boring. A poor sermon in church can be boring too. But this makes it no less important as part of the many factors leading spiritual growth. Like religion, safety has many approaches and aspects, but the crux of the thing is in the respect we have for ourselves and others. This is the root of the "human factor."

Both Easy, One Easier

A BRIEF REVIEW of just a few items that go to make governmental expenditures sky-high and put our national debt into never ending ascension would include these:

- Since the close of World War II, we have loaned, given away or spent well over $100 billion abroad.
- A farm program, started when farmers were in bad shape economically, has cost us some $60 billion (and it's still costing about $5 billion annually).
- We have increased in each of the past six congressional election years the benefits or coverage under old age or unemployment programs.
- We are spending at least $50 billion yearly on national defense and international relations. (This is a minimum estimate—we doubt if anybody in Washington has a very good yardstick on this item).
- For each gain of three people in productive employment over the past three decades, there has been an increase of one person in government employment of civilians.

These facts and figures were incorporated in a talk given several months ago by a United States Steel Corp. official before the Manufacturing Chemists' Association. He presented, along with this citation of pertinent figures, some observations and opinions of his own including this one that we used on this page last month:

"There are two conflicting ideologies in our world today, each championed by a great nation armed to the teeth. We dare not lose that conflict. But some way other than sheer financial extravagance has got to be found for the quite simple reason that whether you are murdered or commit suicide you are nevertheless dead."

That thought is repeated for those who in face of Washington's pell mell rush down the road to bankruptcy, will cite the urgency of the world situation as the reason for inescapable increases on the debit side of the governmental ledger. "How can a people expect Washington to hold the line under such conditions," they ask.

The answer—and a very wise one—comes not only from bankers and industrial executives but from the man on the street or the informed housewife: "Needed increases for defense spending call for strict economy—frequently drastic cuts—in the outlay for non-military items."

No citizen true to real American principles and traditions begrudges or would criticize expenditure of a single dime for defense so long as every safeguard is taken to get 100-cent value for every dollar spent. Likewise, if these defense expenditures of necessity must rise and rise, then only the unthinking would argue against cutting all "civilian" expenditures to the bone.

But apparently that's not what's being done. Here's testimony from Senator Gordon Allott (R., Colo.):

"If the Administration had just held the line on non-military spending and forced the military to tighten some of its procedures, we could have had a balanced budget. Instead we find—along with the new or expanded programs of federal aid—an average of one new federal employe added to the payroll every four minutes of the day."

Some of our brave "new frontiersmen" doubtless will observe that it's pretty easy to sit back and criticize Washington for trying to do something. And we agree. But while such criticism comes easy, it doesn't compare with the ease shown by our elected officials and the myriad of "brains" that surround them in abusing the tax dollar. Tragically, their facility here is threatening in a real way a great nation's economic soundness. And survival.

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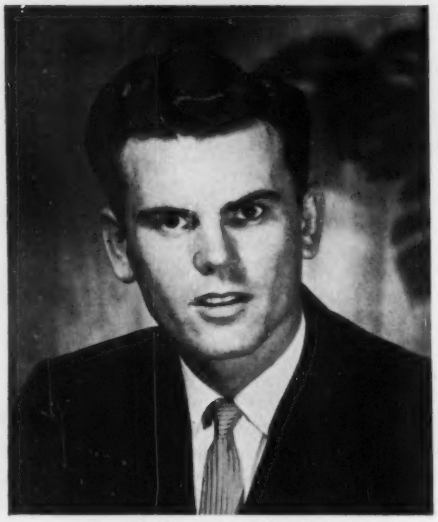

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Ray Long, President of VAREC, has personally instituted new procedures which will guarantee shipment of VAREC's new improved 2500-B Series tank gauges to customers within twenty-four hours of receipt of order.*

To accomplish this unprecedented service to VAREC customers, Long has established a Central Stock, which is under the control of sales and independent of production. From Central Stock in Los Angeles, quantities of standard 2500-B Series tank gauges will be allocated to key VAREC warehouses in San Francisco, Houston, Chicago, and New York City.

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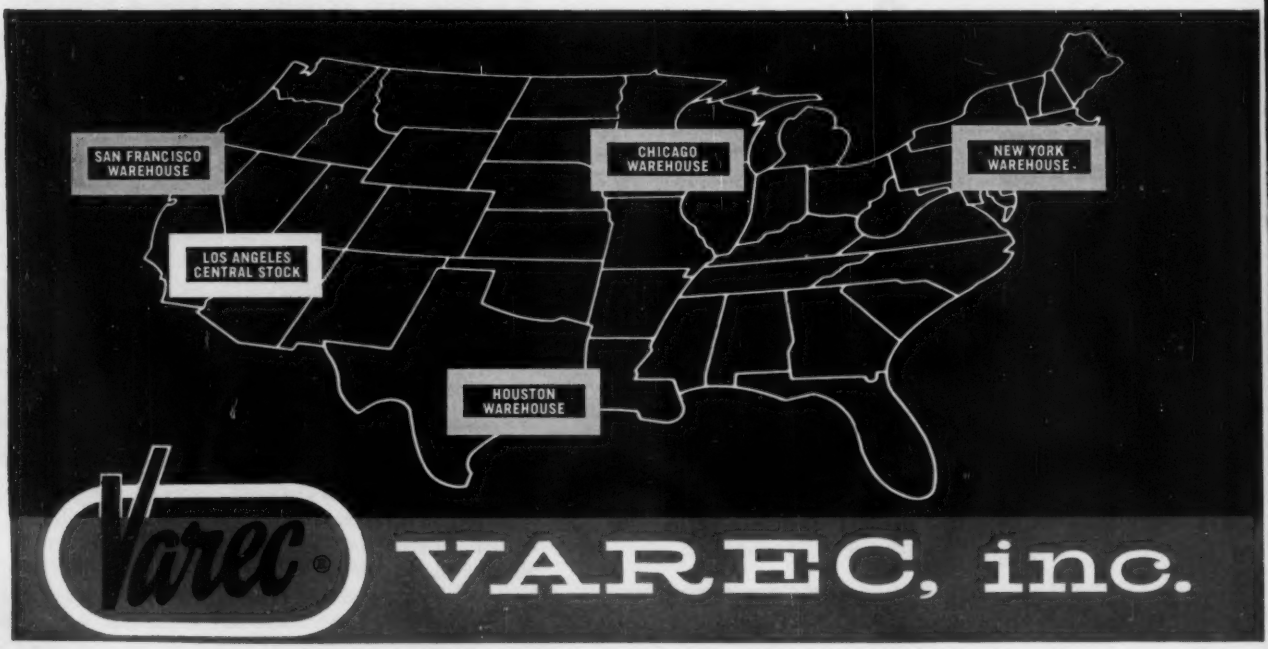
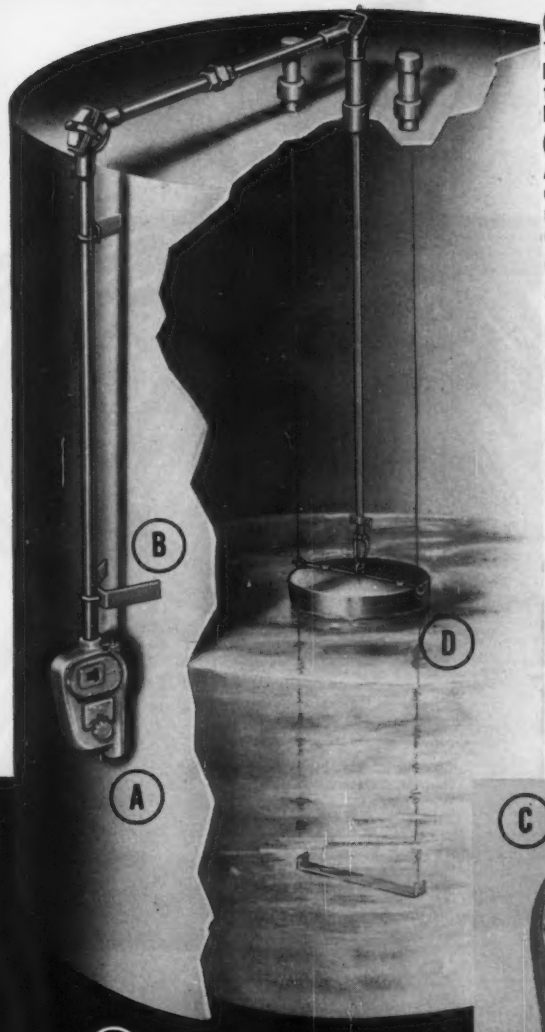
**Effective December 1, 1961 on standard 2500-B Series tank gauges.*



NEW 2500-B TANK GAUGE



(A) "AT GRADE" OR "TANK TOP" INSTALLATION

The new advanced VAREC Model 2500-B Series tank gauge mounts either at the bottom of the tank as a conventional ground reader, with piping coming in from the top of the gauge head, or at the top of the tank with piping coming in from the bottom...without requiring modification or even attitude change of the tank gauge.

(B) NEW "A-FRAME" MOUNTING

A new "A-frame" bracket firmly supports the gauge head apart from the tank in conventional "at grade" mounting as a ground reader...eliminates possibility of measurement error due to vertical shift and allows the option of "front reading" or "side reading" positioning.

(C) OIL-FILLED HEAD AND COUNTER ASSEMBLY

Another standard in the "dual option" design permits the independent filling of the gauge head and the counter assembly for those applications where continuous lubrication or protection from corrosive elements is desired.

(D) NEW CIRCULAR STAINLESS STEEL FLOAT AS STANDARD

New circular type foam glass float, completely jacketed with type 316 stainless steel, offers "dual option" for use in all fixed or floating roof tanks...stainless steel jacket resists "pinholing"—foam glass insures against sinking.

PLUS THESE ADVANTAGES

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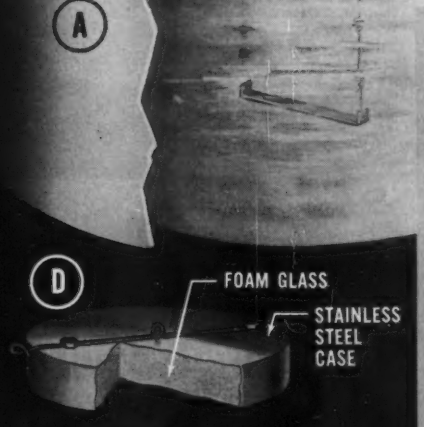
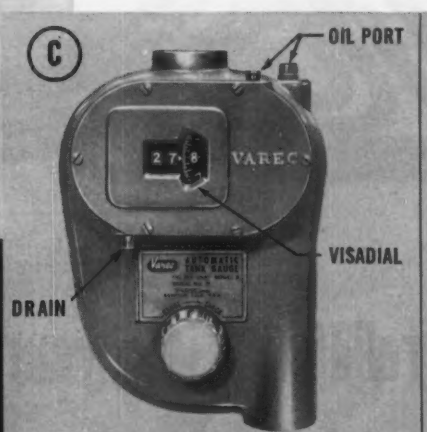
- New simplified design with fewer parts and improved materials offers greater over-all gauge reliability and longer life...permits assembly by unskilled labor.
- New "harness-hitch" connects float in a jiffy...tape and neg'ator motor may be attached to their drums without use of tools.
- VAREC supplies a package gauge, that is everything supplied complete, except the long horizontal-vertical runs of pipe and union.

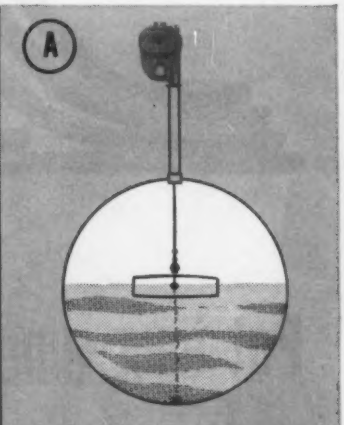
For twenty-four hour delivery of the new Model 2500-B tank gauge, contact your local VAREC sales office. For more information, write for Bulletin CP-3301. Dept. PR-1700-1.



2500-B TANK FLOAT



2500-B TANK GAUGE



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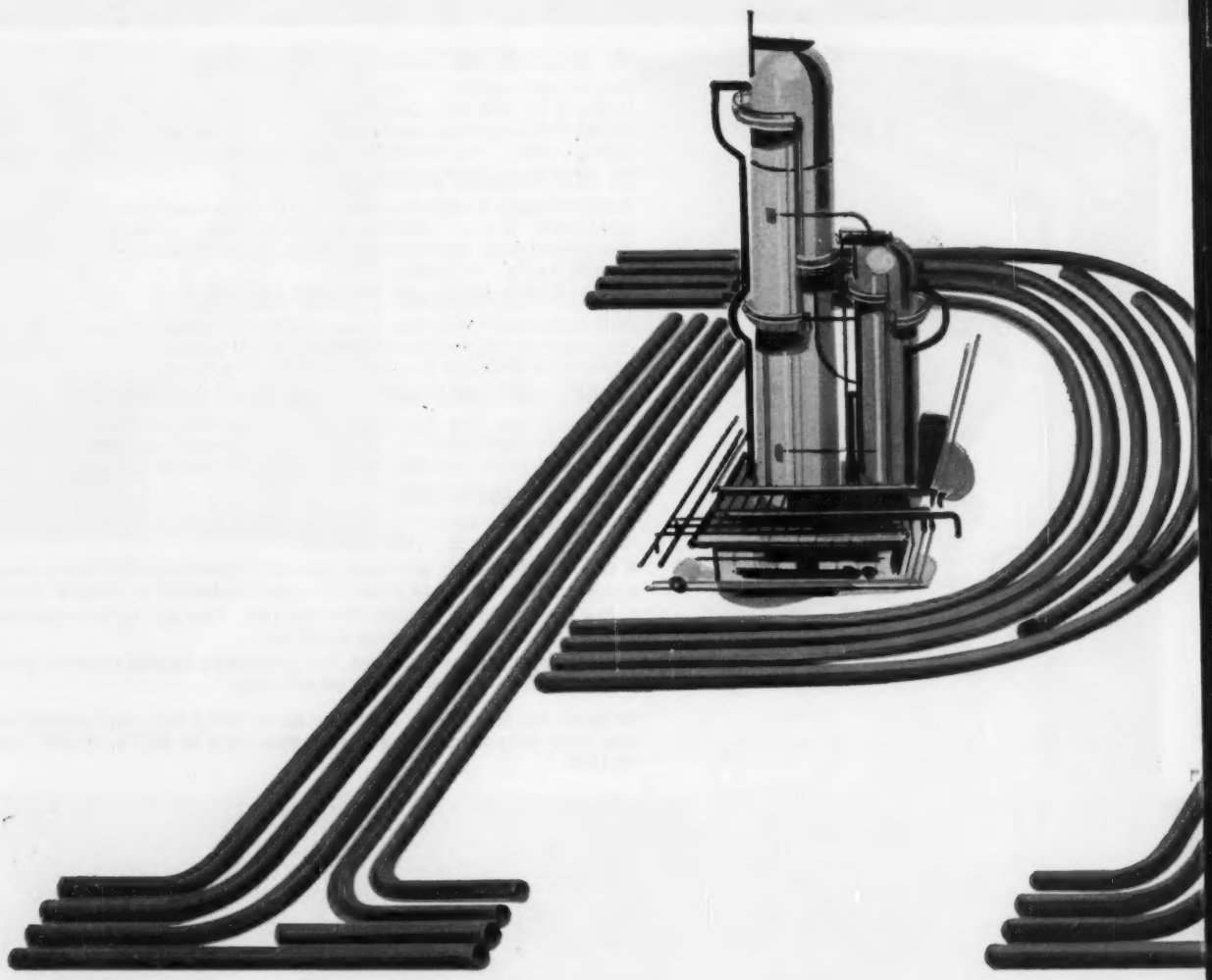

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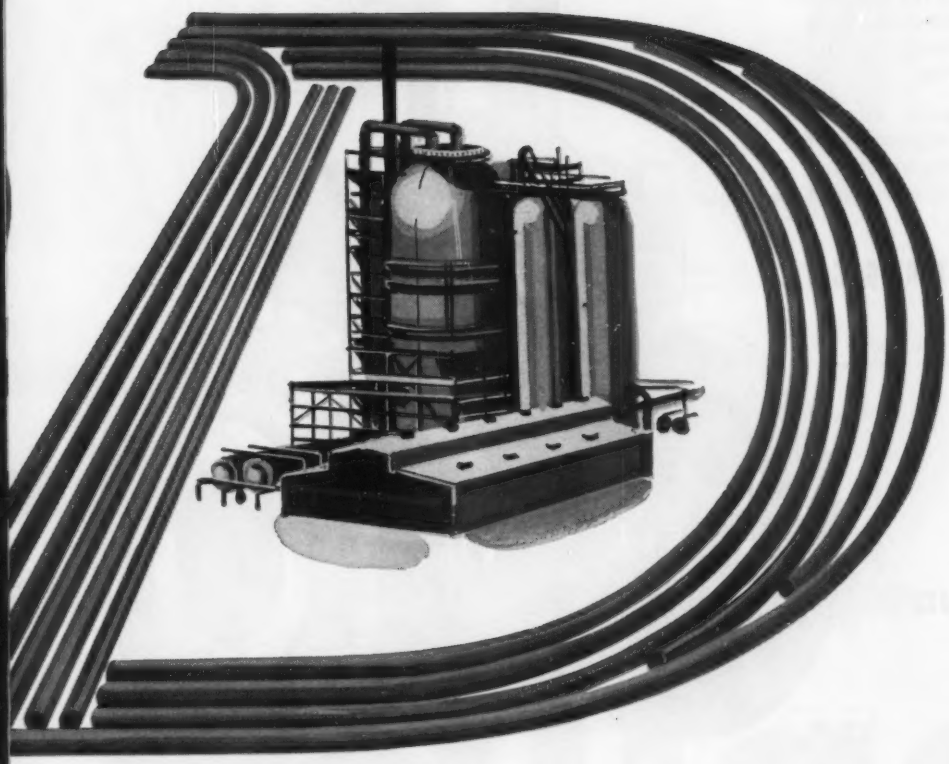

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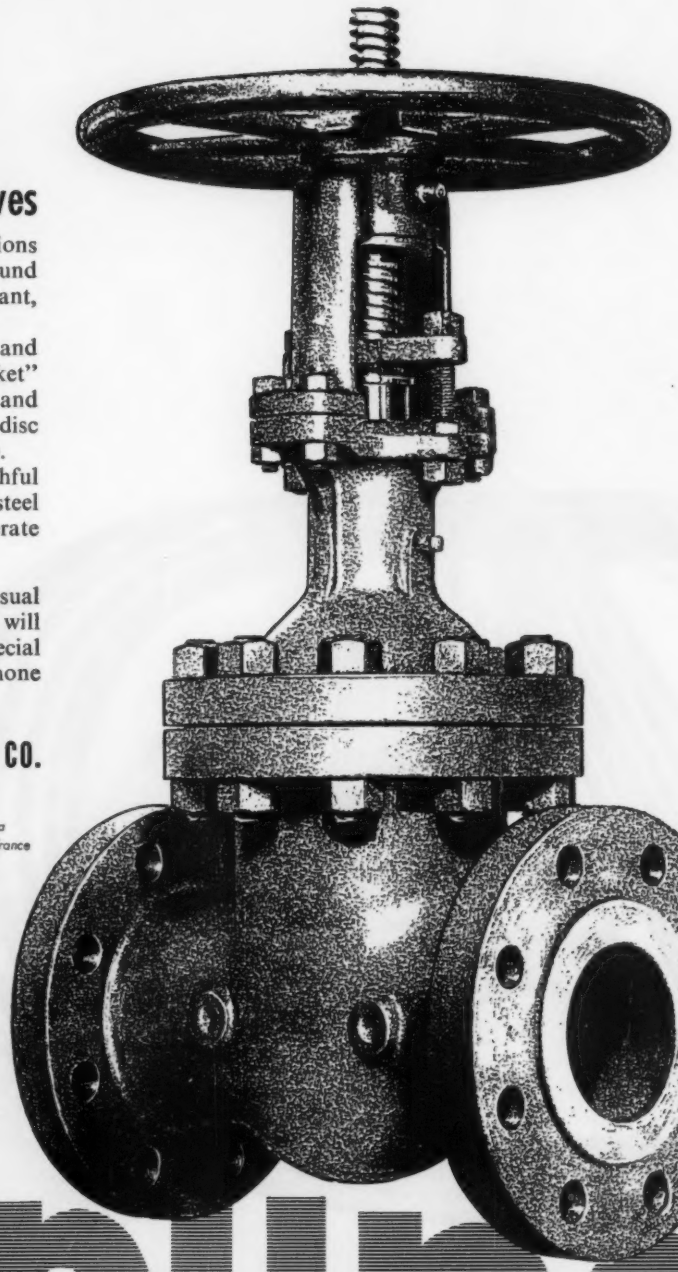

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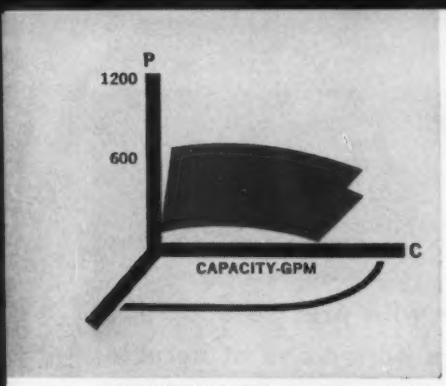

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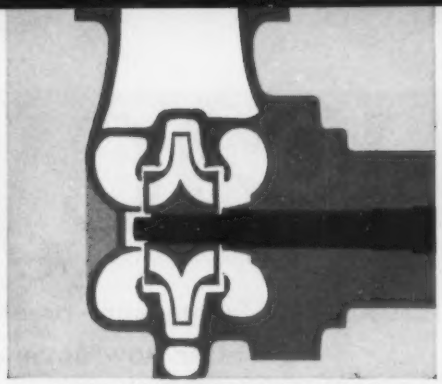

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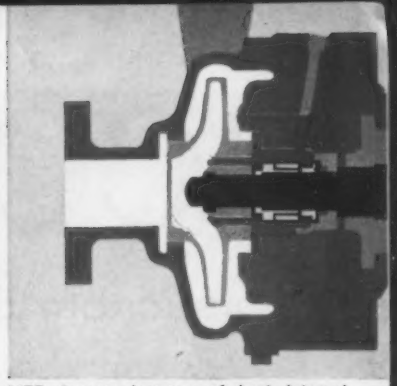
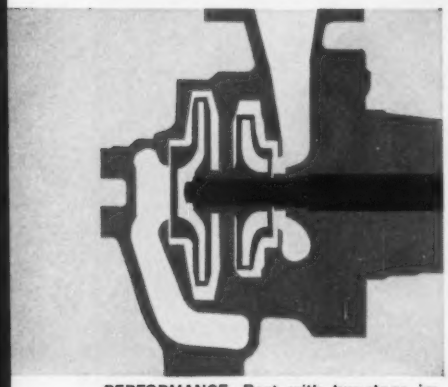
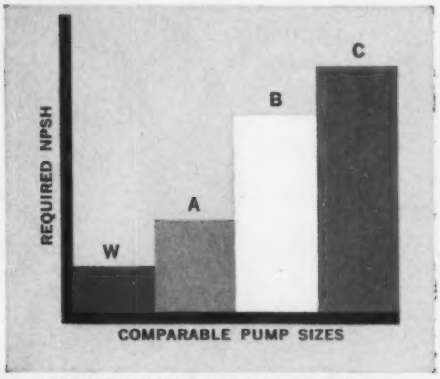


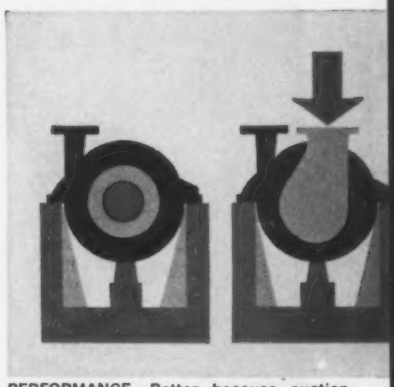
LIFE. Longer because of best internal liquid flow arrangement for flushing seal.



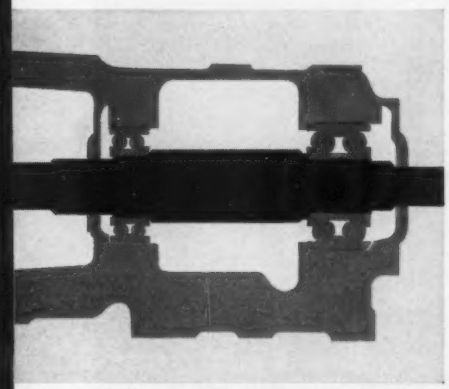
PERFORMANCE. Best with two-stage impeller design handling the higher heads



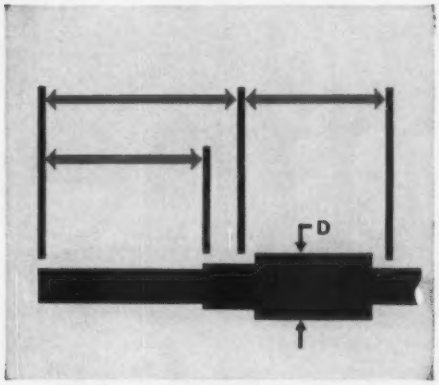
PERFORMANCE. Better because minimum practical NPSH required (validated by test.)



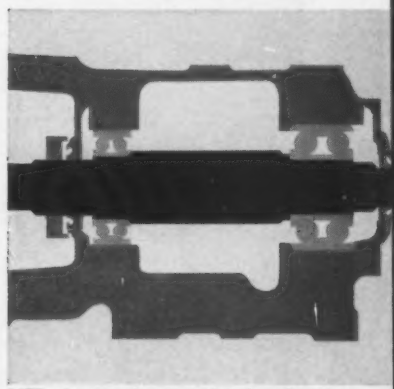
PERFORMANCE. Better because suction position varied to fit your pump installation.



LIFE. Longest because model for model, no heavier shaft bearings are available.



LIFE. Longer because shaft proportions are heavier, second to none. Analyze them!



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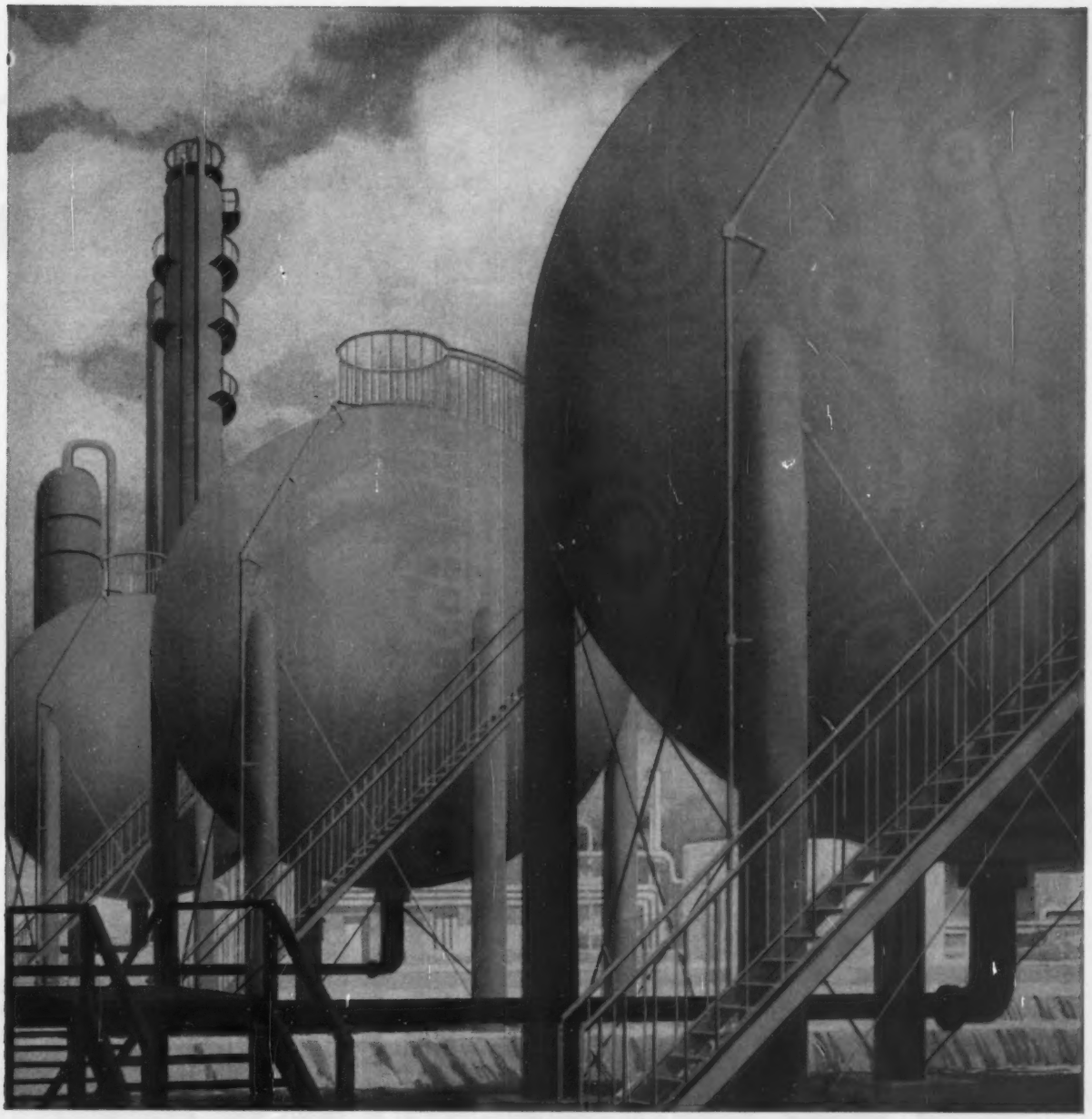

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That's what you get when you specify paints made with M50® Basic Lead Silico Chromate pigment

Paints made with *M50*® Basic Lead Silico Chromate have remarkable resistance to chalking and color change, even in harsh atmospheres.

And Basic Lead Silico Chromate can be tinted in an unusually wide range of colors—colors that can convert your tanks and installations into attractive goodwill builders for you. *M50* pigment also provides excellent rust inhibitive properties and outstanding weather resistance.

M50 pigment can be used in every coat, to build up "Defense-in-Depth" against corrosion and weather-wear.

The anti-corrosive action goes from the primer up through the finish coat. The durability goes from the finish coat down through the primer.

• • •

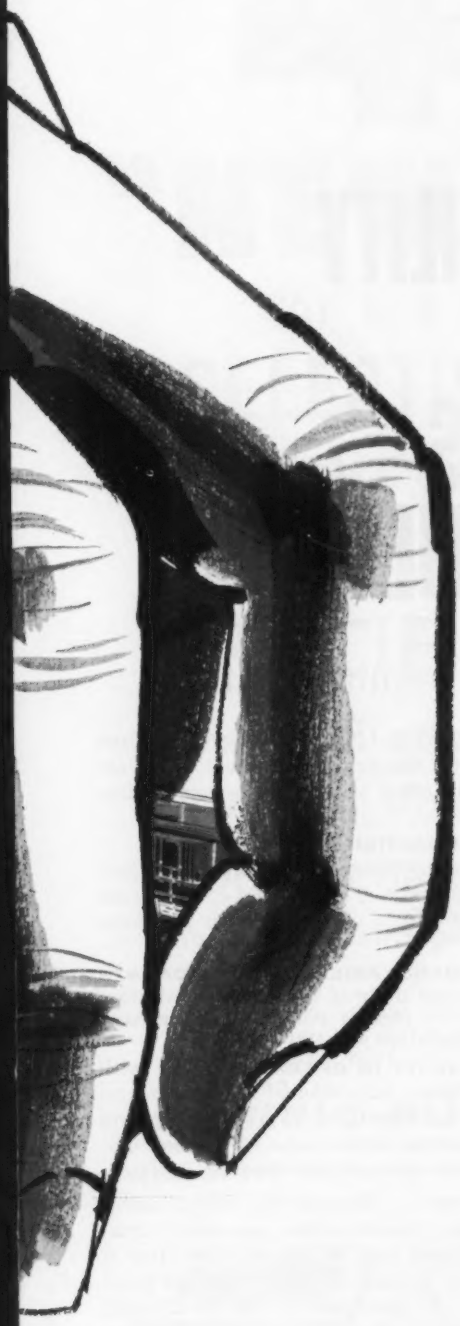
Next time you buy paint for decorative metal protection, specify paints made with *M50* Basic Lead Silico Chromate.

M50 an oncor *Pigment... A Development of* National Lead Company

General Offices: 111 Broadway, New York 6, N.Y.

For more data on advertised products, use cards, last page.

Foster Wheeler ***Heat Engineered*** **products, plants and processes...for the world's industrial progress.**



Experience engineers your plant and puts it where you want it

The ideal objective in planning your process installation is to arrive at the most direct and economical route to your production and quality requirements.

If anything can bring you close to this ideal, it is experience . . . and this is what Foster Wheeler has to offer . . . unusually broad experience in process design, engineering, procurement, construction and plant start-up. The adaptability of this experience has been demonstrated by over 800 successful major installations in 41 nations.

FW engineers have established their ability to meet guarantees for quality, cost and production. In addition, they have found and developed hidden opportunities in many processes for still greater cost reduction and for improved performance. If you are considering a new process installation, it will profit you to discuss your requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y.

FOSTER FW WHEELER

NEW YORK TORONTO LONDON PARIS MILAN TOKYO

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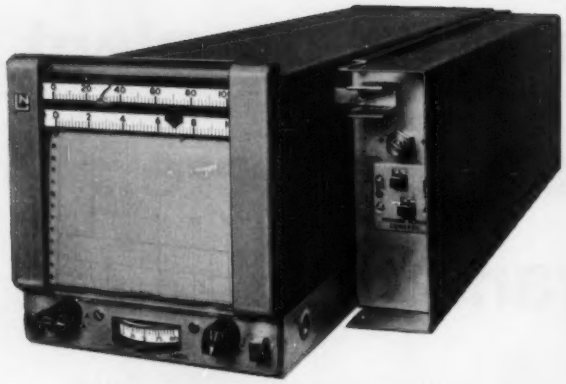


M LINE NEW VERSATILITY IN PROCESS INSTRUMENTATION

Evaluate it yourself, against your control requirements

M-Line Recording Control Station with M-Line TC/EMF Transmitter mounted above.

You'll quickly find that M-Line is the one miniature electronic control that's significantly different. *This* advanced instrumentation offers you a unique combination of advantages:

WIDEST SCOPE OF COMPATIBILITY IN OPERATION . . . can be used with almost any transmitters supplying a signal of 0.4 to 2 ma d-c, 0 to 4 ma d-c, 1 to 5 ma d-c, 4 to 20 ma d-c, 10 to 50 ma d-c, or 0 to 25 volts d-c output (complete list on request);

UNMATCHED INTERCHANGEABILITY OF COMPONENTS . . . display and/or control units of varying sophistication can be readily substituted (simply plugged into the basic stations) even after installation and start-up;

OUTSTANDING FLEXIBILITY IN OPERATION . . . with set-point station, controller, auto-manual station and recorder (or indicator) independently removable, process will remain on control—automatic or manual—while these components are individually checked, serviced or replaced.

When your process demands competitively-priced instrumentation, with delivery in 6 weeks or less, you should investigate the sound investment that M-Line provides. Buy it and try it . . . you'll find M-Line the most advanced miniature instrumentation in electronic control. For more details, call your nearest L&N Field Office or write to 4923 Stenton Ave., Philadelphia 44.

LEEDS & NORTHRUP
Pioneers in Precision

4 "NEWS" for the SELECTIVE BUYER!

PACIFIC

types DS and DL

Double Volute

Double Suction

single stage centrifugal pumps

Write for Bulletin 143

PACIFIC PUMPS

Inc... A Division of Dresser Industries, Inc.

HUNTINGTON PARK, CALIFORNIA, U.S.A.

PACIFIC

CENTRIFUGAL PUMPS FOR PETROLEUM, CHEMICAL, UTILITY & GENERAL INDUSTRIES
OIL WELL PUMPS

DRESSER INDUSTRIES INC.

OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL

1 NEW QUALITY – All DS and DL pumps are skillfully moulded from meticulously fabricated patterns to provide smooth exterior and interior contours and controlled case thicknesses. All parts in contact with liquid being pumped may be fabricated from any commercially available ferrous or non-ferrous metal.

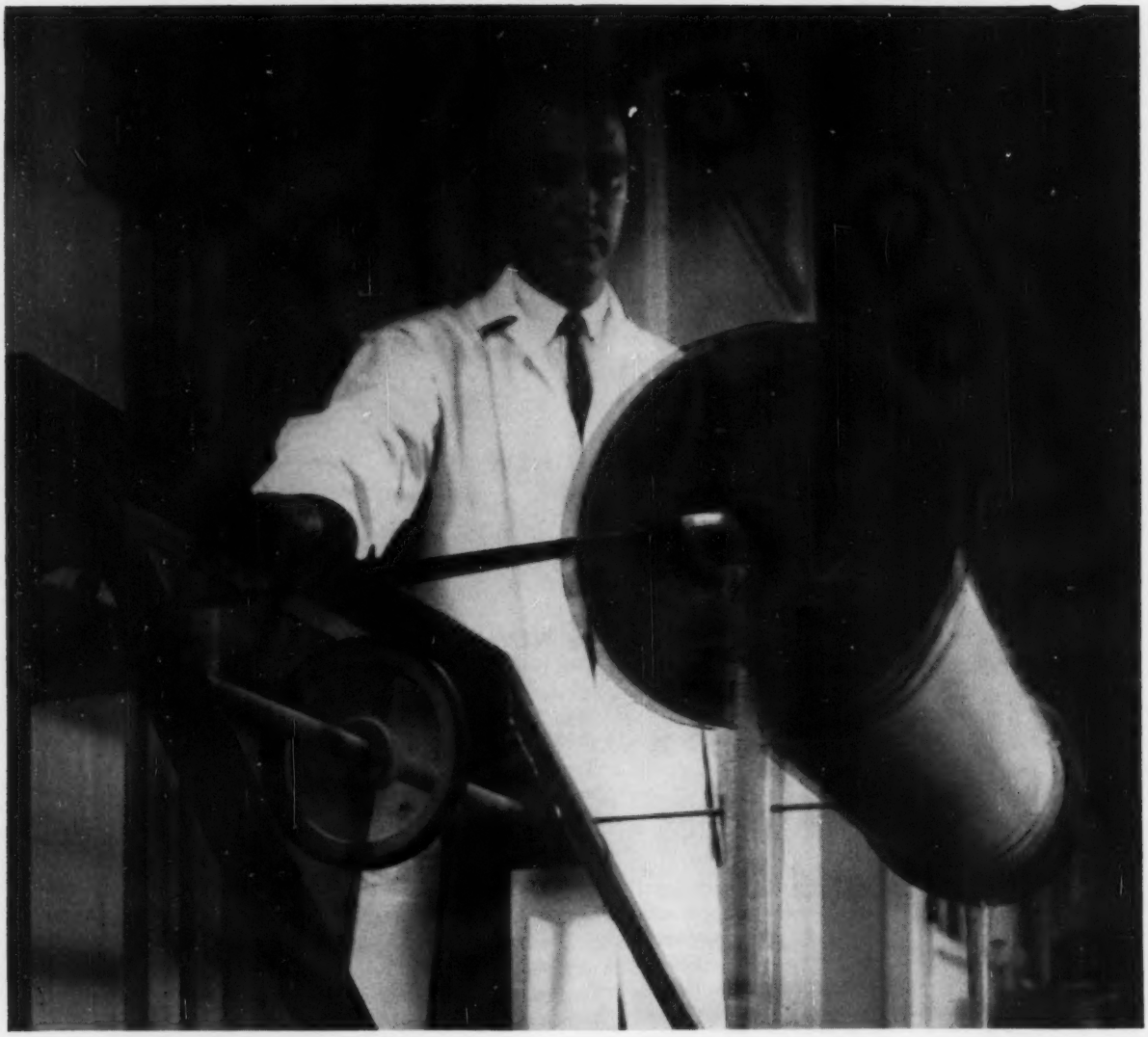
2 NEW DESIGN – Types DS and DL are *double volute* with double suction impeller. Shaft assemblies are dynamically balanced, radially and axially for minimum wear. Cases are axially split with nozzles cast integral with lower half. Type DS has provisions for water cooled packing boxes and bearings. Type DL is air cooled. Available with conventional packing or mechanical seals. Internal assemblies are mounted on only six shaft size groups for maximum parts interchangeability between pump sizes.

3 NEW PERFORMANCE – With a capacity range from 2,000 to 13,000 GPM and differential heads to 375 ft., the 22 sizes of type DS and the 13 sizes of type DL, make it unnecessary to compromise your specific pumping requirements – i. e., optimum efficiency with low NSPH.

4 NEW ECONOMY – Pacific types DS and DL pumps offer threefold economy. First, engineering skill and expert craftsmanship reduce the initial cost appreciably. Second, the balanced hydraulic design results in minimum wear on moving parts insuring higher sustained efficiency. Third, rapid disassembly plus maximum spare parts interchangeability between pump sizes assures reduced maintenance costs – less down time.

CP-26

For more data on advertised products, use cards, last page.



"K&M" ZEBRA Pipe Insulation *proves its toughness before it leaves home!* In torture tests by hard-to-satisfy K&M engineers, "K&M" Zebra® proves its ability to withstand heat, shock and vibration. Its multi-layer, sectional-type construction of calcium-silicate—asbestos bonded felts requires no babying on the job. Demonstrates a deflection at breaking point 2 to 4 times that of ordinary insulation. Stands up under periodic removal for line inspection. "K&M"® Zebra Pipe Insulation prevents heat loss indoors and outdoors, through a temperature range from 200 F to 1200 F. Its smooth, dust-free surface facilitates handling (no skin irritations or penetration). Half-sections and sizes available through 24″ pipe diameters. For more information, write: *Keasbey & Mattison Company, Ambler, Pa., Dept. I-2111.*

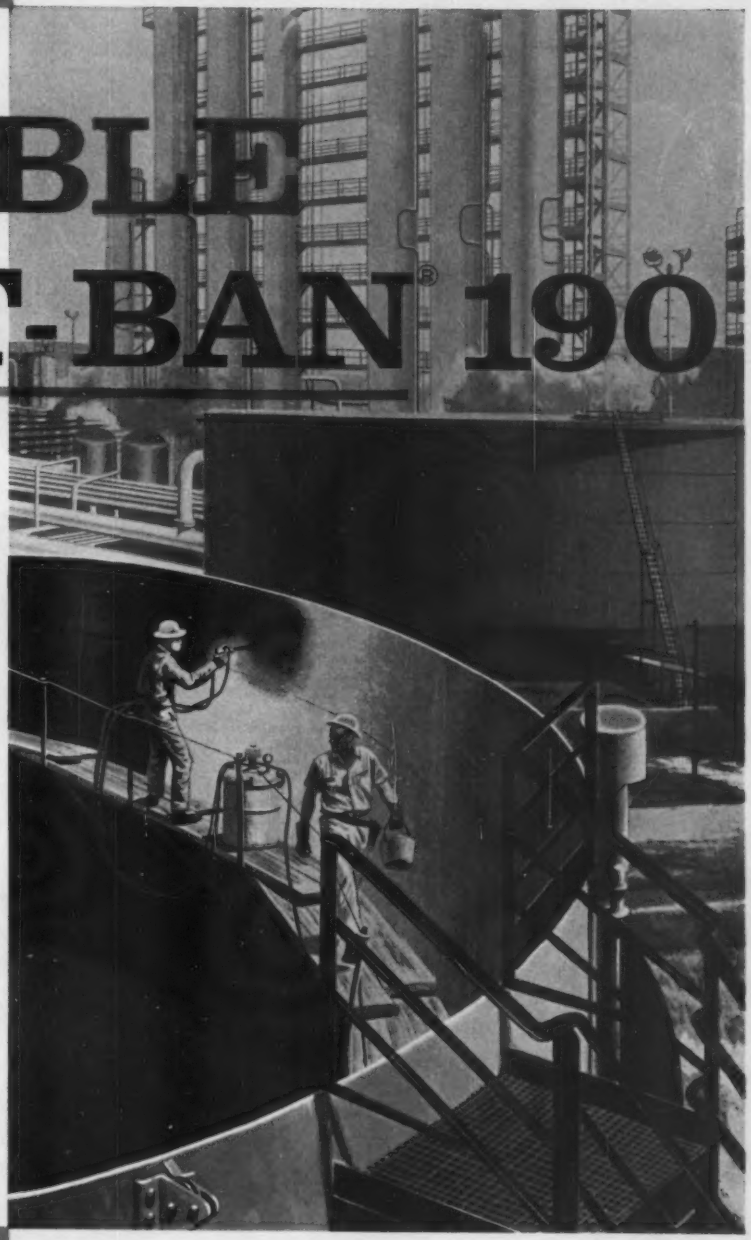
K·M BEST IN ASBESTOS

Keasbey & Mattison at Ambler

REACTS WITH THE STEEL...

...eliminates underfilm corrosion in finished product tanks

HUMBLE RUST-BAN® 190



This remarkable new coating bonds so perfectly to steel that you cannot discover an interface! The reason? *RUST-BAN* 190 reacts *chemically* with the steel. The resulting bond is inseparable . . . completely eliminating underfilm corrosion.

The hard, abrasion-resistant coating of 100% inorganic zinc silicate is virtually impervious to the scraping action of floating roofs. RUST-BAN 190 is nonflammable, does not contaminate even high-purity products.

When properly applied and cured (with its companion RUST BAN 195) RUST-BAN 190 provides many years of protection at far lower annual cost.

For complete information about RUST-BAN 190 and other Humble protective coatings, call your Humble salesman or contact Humble Oil & Refining Company, Houston, Texas.

ENCO PRODUCTS

HUMBLE OIL & REFINING CO.

America's Leading ENergy COmpany

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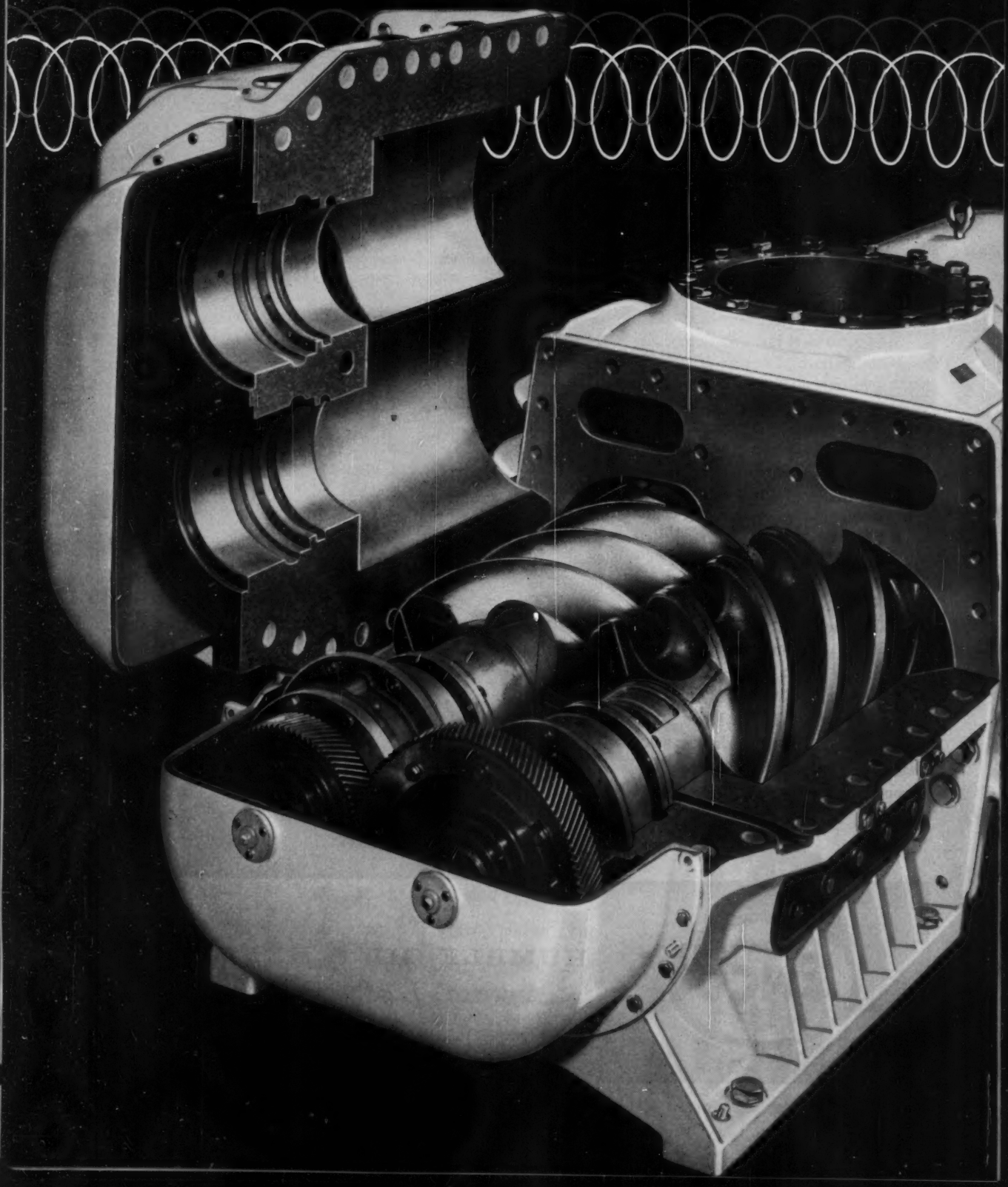
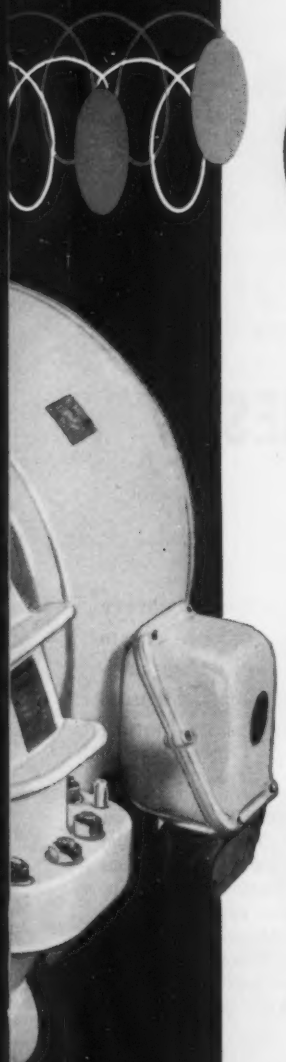
MORE BLUE CHIP COMPANIES BUY F-M COMPRESSORS...





BECAUSE MECHANICAL SIMPLICITY MEANS FAR LESS COST!

F-M ROTARY COMPRESSORS

More and more, industrial leaders are looking-to (and buying) Fairbanks Morse leadership in Compressor design. Why? Because the unique, mechanical simplicity of this *rotary* design combines maximum efficiency and reliability with low initial cost—low maintenance requirements—minimum operating costs. *And skid-mounting* cuts installation time—puts you on stream faster.

The advanced design of the F-M Axial Flow Rotary Compressor features *helical-shaped* rotors for smooth, economical compression . . . with oil-free delivery, surge-free operation on a wide variety of gases.

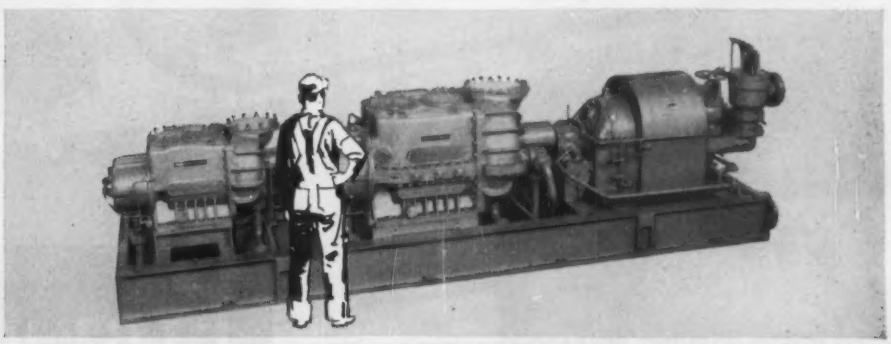
F-M Rotary Compressors have no reciprocating parts, no valves, no metal-to-metal contact in the compression chamber. Result? Minimum "down-time" expense. They save space—produce minimum vibration—provide stable performance with speed flexibility. Every Rotary Compressor built features famous Fairbanks Morse quality craftsmanship.

With capacities up to 21,000 cfm—and pressures up to 250 psig, F-M Rotary Compressors are a versatile asset to many operations. Discover how they can step up the efficiency of *your* operation . . . and cut maintenance and installation costs as well. Write: **Fairbanks, Morse & Co., Director of Marketing, Compressor Division: Beloit, Wisconsin.**

THESE INDUSTRIAL LEADERS HAVE BOUGHT F-M LEADERSHIP IN COMPRESSOR DESIGN!

(What Benefits Them Can Benefit YOU)

The Algoma Steel Corporation, Limited
American Metal Climax, Inc.
C F Braun & Co.
Celanese Chemical Co.
Copolymer Rubber & Chemical Corp.
Cyanamid of Canada, Ltd.
Deere & Company
Foster Wheeler Corporation
M. W. Kellogg Co.
Monsanto Chemical Co.
The Ralph M. Parsons Company
Phillips Chemical Co.
Scientific Design Co., Inc.
Shell Chemical Company
St. Paul Ammonia Products Co.
Union Carbide Chemicals Company
United Refining Co.



Skid-Mounted, Tandem Rotary Compressor ready for installation at Deere & Company, Waterloo Tractor Works.

Model 200L3/132L3 Fairbanks-Morse Rotary Air Compressor for 12,000 cfm, 110 psig. with 2600 h.p. steam turbine drive.

FAIRBANKS MORSE
A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY

HERE IS A QUICK, EASY WAY TO DETERMINE TRUE ECONOMIC INSULATION THICKNESS

A simple evaluation system from Owens-Corning called **DIVIDEND ENGINEERING**

Now you can determine the "thermo-economic" performance of any Fiberglas* insulation in any power or process application—quickly, easily—and *accurately*.

Data never available before the electronic computer age have been compiled into a simple, easy reference system that can save countless hours of time. This system is called Dividend Engineering. It takes into account *all* the fixed and variable factors that affect the true economic thickness of the insulation: areas to be insulated, cost of heat, capital investment in insulation, maintenance, installation, capital recovery and depreciation. It also includes "hidden" costs never before readily computable. The dollars-and-cents difference between Dividend Engineering figures and those arrived at through previous evaluation methods often is astonishing.

SEND FOR THIS FREE BOOKLET on Dividend Engineering. It shows how, with the help of this system, you can not only design new plants to produce maximum return on investment; you can also upgrade existing installations to operate more efficiently. Write today to: Owens-Corning Fiberglas Corporation, Industrial & Commercial Division, 717 Fifth Avenue, New York 22, New York.

OWENS-CORNING RESEARCH pioneers new ideas in

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WHAT Vogt CAN DO FOR YOU..

Bulletin E-1 shows Vogt's advanced designs in heat exchangers, reactors, oil chillers, crystallizers, pressure vessels, steam generators and ice making and refrigerating machinery for countless applications in petroleum refineries, chemical plants, power plants and related industries.

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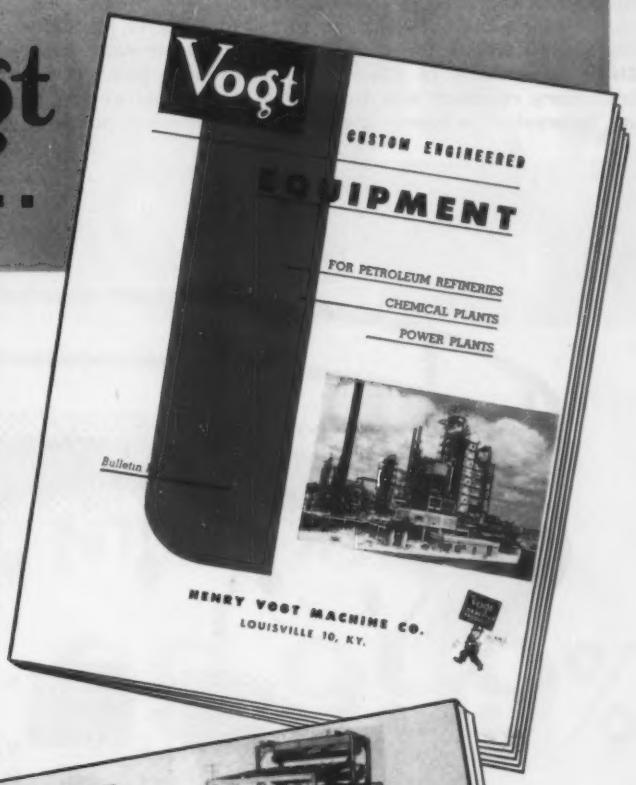

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Mail Coupon today

Gas reforming hits a new high Engineering news was made in France recently, when a Chemico high-pressure gas reform furnace operating at 250 psi was placed on stream. Prior to the completion of this project, no gas reformer in the world had ever operated at pressures above 175 psi. Design innovations incorporated in this plant reduce compression requirements and increase heat recovery.

This historic breakthrough in gas reforming is indicative of the skill and experience which Chemico brings to all process engineering problems. Chemico services to clients in the process industries range from initial laboratory research and testing to final construction and start-up. If you are interested in learning more about Chemico, write to "Department B".

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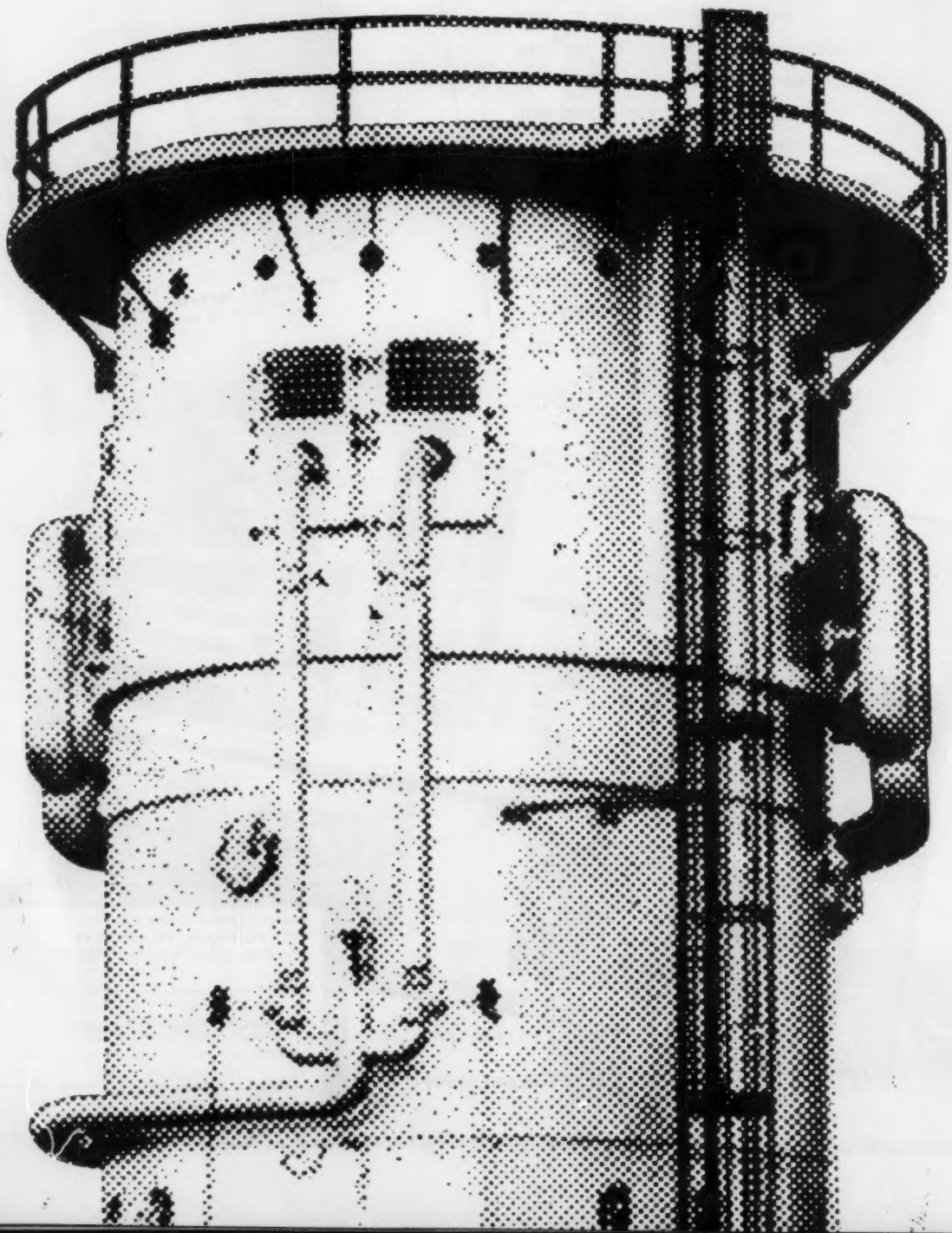


SUPAIRCO TYPE N

High purity automatic package nitrogen plants N_2

producing nitrogen by low temperature distillation of air

Typical automatic control panel

NITROGEN

99.999%

INERT · PURE · DRY

Impurities:
Oxygen — less than 10 ppm
Water — less than 2 ppm
Argon — approximately 1000 ppm

SUPAIRCO Type N nitrogen plants* are automatic, low pressure, package type units available in sizes from 3000 scfh to 100,000 scfh.

These plants are a reliable and economical source of maximum purity (99.999%) nitrogen. With this equipment you can *eliminate* costly product rejections, *lower* operating costs, and *reduce* quality control procedures. For more information, write to:

SUPERIOR AIR PRODUCTS COMPANY

132 Malvern Street, Newark 5, New Jersey · MArket 3-5715

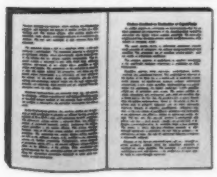
**Manufactured under licence from Petrocarbon Developments, Ltd., London*

That odor you smell is money escaping!

The odorous fumes coming from your plant stacks are probably costing you much more than the good will of your employees and neighbors. For these odors often represent a wasted asset . . . a missed opportunity to lower your costs . . . through conversion of fumes to BTU's for use in processing, plant heating, or other operations.

Hundreds of installations in chemical plants . . . producing a wide variety of compounds including maleic and phthalic anhydride, synthetic fibers, resins, oils, varnishes and many others . . . have proven the economy and feasibility of converting objectionable organic and other combustible waste gases to money-saving fuels through Catalytic Combustion. In this proven process, all-metal catalysts and catalytic systems oxidize these gases by *low temperature, flameless combustion* . . . to give you usable energy and a low temperature, odorless discharge from your stacks.

High pressure processes, such as those for ethylene oxide and nitric acid, provide special opportunities for savings through tail gas power recovery. Incidental benefits often include reduced fire hazards, simplified cleaning maintenance, healthier working conditions . . . and better community relations.



For more details *on the economies possible write Dept. F for this brochure. Or, better yet, give us a few facts on your waste gas problem so we can make specific suggestions.*

CATALYTIC COMBUSTION CORPORATION
4725 Fourteenth Street • Detroit 8, Michigan
A SUBSIDIARY OF UNIVERSAL OIL PRODUCTS COMPANY

IF IT'S BY CHIYODA IT'S BOUND TO BE GOOD

By "Good" we mean that CHIYODA's Process Plant Specialists (Engineering, Fabrication and Construction) have the technical know-how and modern, completely equipped facilities to handle your Process Plant needs and problems—large or small—from drawing-board to finished product and produce the results that count: Peerless quality, competitive prices and early delivery.

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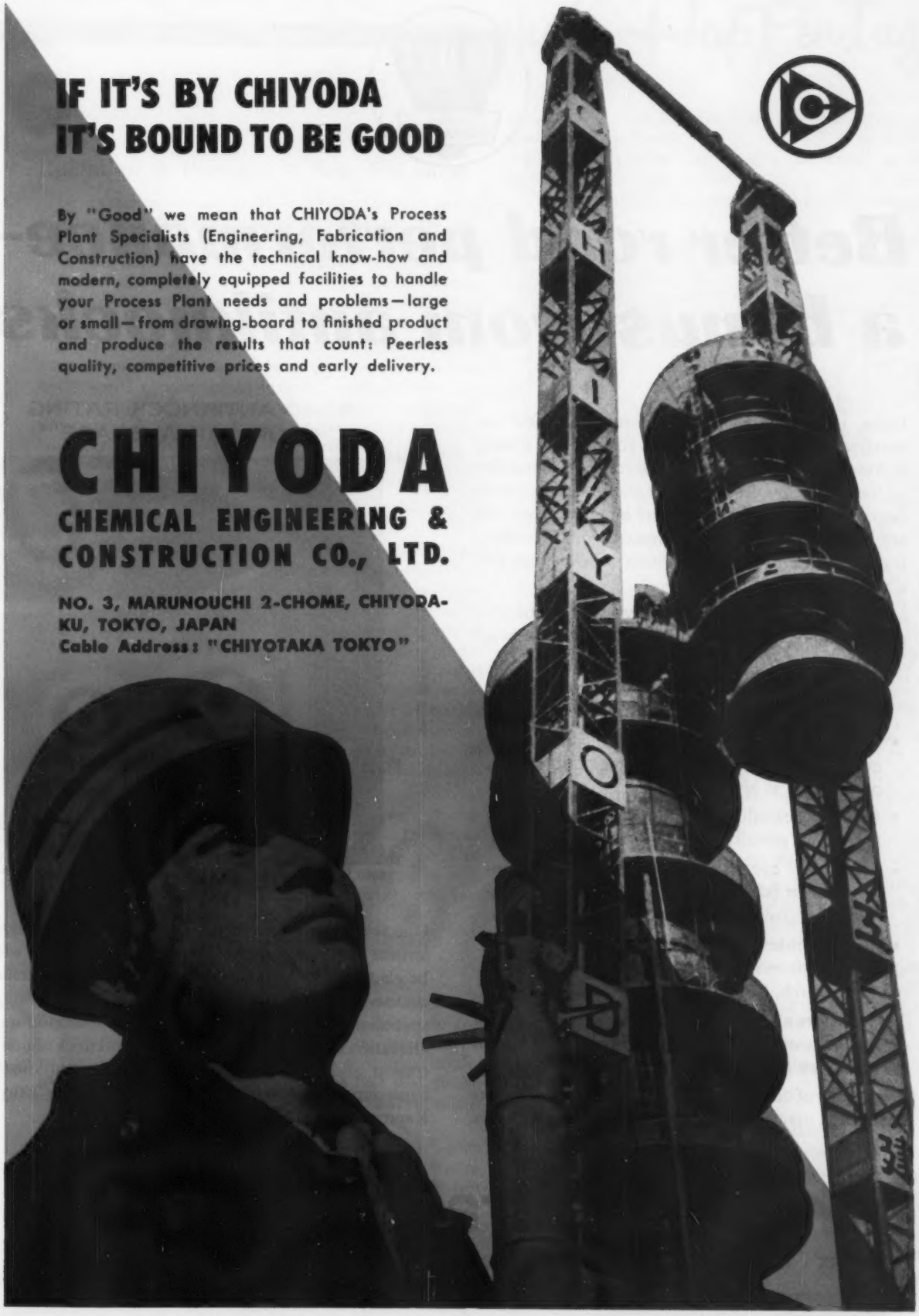


Better road performance— a bonus from antiknocks

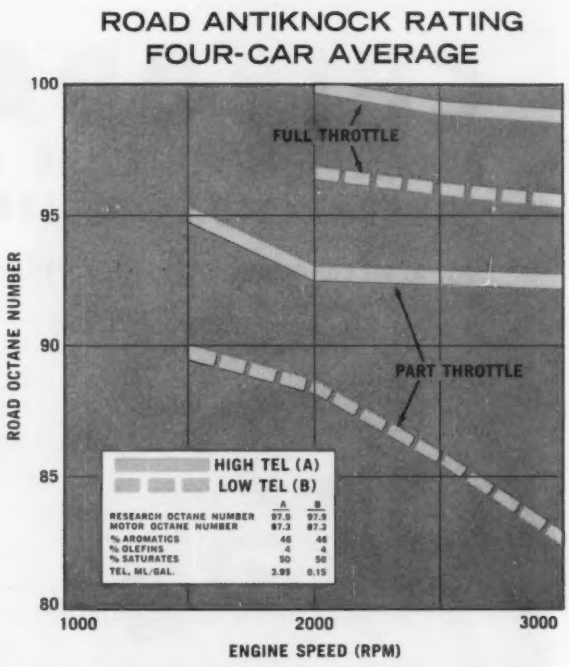
Better road performance means more satisfied customers. And, in many cars, this road-octane quality is greater in fuels having high lead concentrations than in fuels with low lead levels at the same laboratory octane numbers. Because octane numbers from lead are equal or lower in cost compared with processing, it makes sense to get your octanes this way and gain a *road bonus*.

The extra performance you get from antiknock octanes can be rewarding to you in several other ways:

- The range of antiknocks now available permits you to choose the one best suited to your special needs in terms of cost effectiveness.
- Decreased gasoline sensitivity from the use of antiknocks results in better engine performance, particularly at high speeds.
- Refining flexibility can be increased with antiknocks, to permit most profitable use of stocks.
- Antiknocks can also reduce or delay capital investment in octane-improvement equipment because they provide a cushion for increased octanes.
- Today, antiknock compounds are your best octane-improvement buy—whether you figure cost on Research, Motor or Road ratings.

These factors all add up to the need for a new look at octane-improvement costs and a reappraisal of the balance between antiknocks and processing.

Evaluation of octane-improvement methods and costs has been a major concern with Ethyl for many years.



One thing we have learned is that there is no single answer that fits every situation. Our technologists will be glad to work with you in evaluating your specific octane-improvement program. Linear programming specialists will assist in determining most economical allocation of components, optimum antiknock concentration, and selection of the most effective antiknock compounds for your situation. Just call your Ethyl Representative for the complete story.

Ethyl Corporation

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TECHNOLOGY

Radiation + Pressure = New Polymers

By exposing substances to gamma radiation under high pressure, National Bureau of Standards has prepared polymers from normally non-polymerizing monomers such as carbon disulfide. Reaction is initiated by radiation and favored by pressure. With such combination of conditions, solid polymers can be obtained from monomers which, at best, normally produce oils.

Many molecules that have double or triple bonds in their chemical formulas do not form macromolecules under usual conditions. In general, when attempts are made to polymerize such molecules, chemical equilibrium shifts toward monomer instead of polymer production. However, if high pressure is applied, equilibrium will be displaced to favor polymerization. Pressure also increases rates of certain reactions producing high polymers, at expense of other reactions that would tend to prevent polymer formation.

Initial studies have been conducted on *n*-perfluoroheptene-1, a-methylstyrene, and carbon disulfide. When perfluoroheptene was subjected to appropriate pressure and radiation, moderate amount of medium-molecular-weight polymer was obtained. Data show that pressures of 11,000 to 15,000 atm at room temperature accelerate rate of polymerization of perfluoroheptene by factor of about 30 over rate at atmospheric pressure. Intrinsic viscosities and solubilities of samples of these polymers in boiling benzene and other solvents reveal that molecular weight is higher at lower dose rates. Thermal decomposition studies for highest melting sample indicate number average molecular weight exceeding 5,000.

Polymerization, in general, follows three-step procedure: initiation, propagation, and termination. In Bureau work, radiation initiates the polymerization by breaking up some of monomers. Until expended, fragments thus produced diffuse throughout medium, collide, and fuse with monomers to form polymeric chains.

Operation 'mudpie'

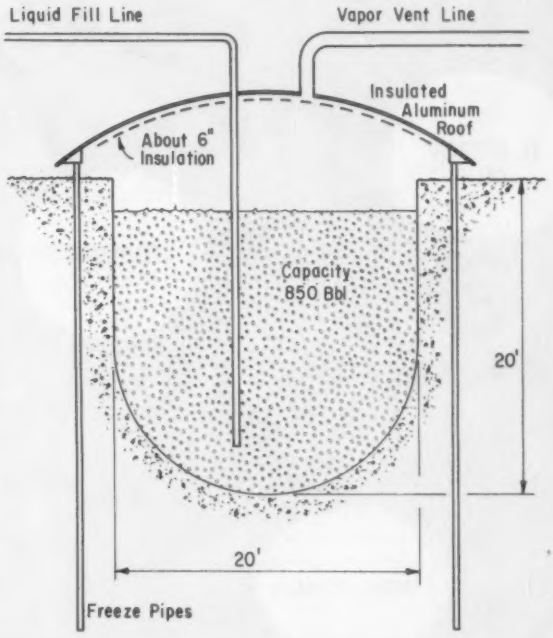
New concept in low temperature storage of methane: Excavated earthen storage cavity with no insulation and no liner—in other words, "bare hole in the ground with a cover on it." Extensive research and theoretical analysis prove pit's economic feasibility and fact that frozen earth provides adequate barrier for containing minus 258° F liquid methane.

Developed by Constock Pritchard Corp. and Conch Methane Services, the 850-barrel pit is capped by insulated roof. Construction details: "Mudpie" is 20-feet diameter cavity, 20 feet deep with aluminum roof hermetically sealed to ground providing gas-tight vessel. How to make "mudpie":

(1) Pre-freeze ground surrounding area to be excavated with external refrigerant (propane refrigeration used for initial freeze).

(2) When frost boundary has moved inward to cavity wall radius, start excavation.

(3) On completion of excavation, install cavity roof.



(4) Cool cavity walls slowly to avoid thermal shock by spraying with LNG, then fill.

Idea for "operation mudpie" came from Dr. C. M. Sliepcevich, consulting chemical engineer, University of Oklahoma.

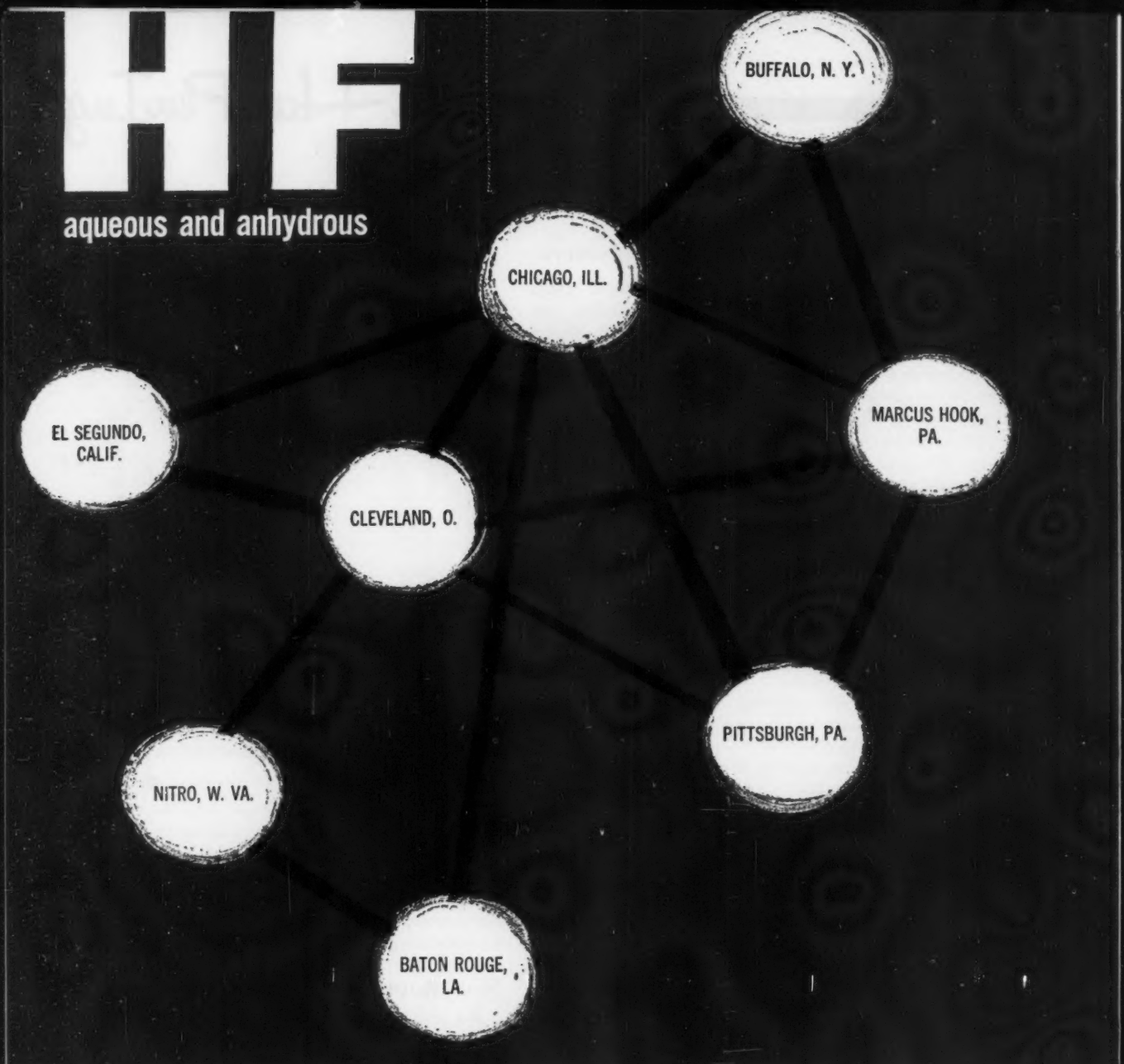
New fluid flow measurement

Big technical break-through in fluid flow measurement using radioisotopes culminates nine months research program by Automation Industries. Company has perfected unique new flow measurement method several times more accurate than anything now commercially available.

Although these new methods using radioisotopes were developed primarily for use in petroleum refining, it's expected they will find application in such fields as hydroelectric installations, cross country pipelines and chemical process control systems.

Ions and the smog gremlin

It has been suggested that ions in the air exert large physiological effects and may have some bearing on smog. Abnormal ion counts in vicinity of traffic arteries have been observed, so some time ago, Standard of Ohio began cooperative tests with Philco to explore nature of ions in automobile exhaust gases. What they found: Since engine oil consumption, type of oil used, and en-



General Chemical's supply network is built around your needs for HF

General Chemical's multiple production facilities for anhydrous and aqueous Hydrofluoric Acid make us the *only* supplier to offer shipment from more than one plant! Our plants are located at Baton Rouge, La.; Marcus Hook, Pa.; and Nitro, W. Va. Deliveries of aqueous acid are also made from five strategically-located bulk storage plants in Buffalo, Chicago, Cleveland, El Segundo (California), and Pittsburgh.

This smoothly-coordinated production and delivery system is backed by a long lifeline of raw material sources: fluorspar reserves, mines, mills, and large sulfuric acid capacity.

Call or write your nearest General Chemical office for information, prices, delivery. Make General Chemical your HQ for HF!

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N.Y.

gine's general condition appear to greatly affect ion level, clean engine was used in tests, and all engine variables were held as constant as possible. Different fuel compositions were tested. All common gasoline additives, and particularly lead, increased ion content. Positive ions were more prevalent during acceleration and during engine warm-up (latter probably being due to large amounts of water condensation droplets), while negative ions prevailed during deceleration.

Test data appear to show that ions in automobile exhaust gases are largely charged particulate matter with little, if any, free charged molecular species. Ninety percent or more of particulate matter can be removed by electrostatic means. This technique could be applied to automotive engines in future if it becomes necessary to remove particulate matter in exhaust gases.

Electrification a fire factor to watch

A theory for generation of charge in hydrocarbons flowing past solid surfaces has been worked out by Jerome Gavis and H. E. Hoelscher of Johns Hopkins University Chemical Engineering Department. Theory explains process in turbulent pipe flow, with emphasis on range of liquid conductivity, velocity, pipe diameter, and pipe length, wherein greatest danger lies. Well established by experiments, method offers equation which gives correlation applicable to turbulent pipe flow, and which can be used when dimensions of system and conductivity of hydrocarbon fluid and its other physical properties are known. Method was discussed at Chicago API meeting, Refining Division.

PRODUCTS

Silicones get help from new additives

Additives for stabilizing silicone lubricants against oxidation and gelation, so that useful life at temperatures up to 600° F is lengthened 30 to 500 fold have been developed by U.S. Naval Research Laboratory in Washington. Cerium, one of metal-amine inhibitors, was found to give best results, lengthening period before gelation as much as 500 times. Other NRL reaction products are: Iron, chromium and praseodymium.

Silicone liquids have been limited in their use by tendency to gel above 400°F. One big advantage they have, however, is ability to retain desirable lubricating properties down to minus 65° F.

Dow makes new paint solvent

Unique, stabilized methylene chloride for use in aerosol-type pressure paints and paint systems in contact with aluminum or combinations of aluminum with iron, has been developed by Dow Chemical. Solvent characteristics: Strong solvating effect on resins, non-flammable, and low toxicity. It has special use in pressurized paints because specially designed inhibitor system reduces attack on aluminum, reduces catalytic reactions triggered by iron and gives superior stability in solvent blends with toluene and range of aromatic solvents. Other advantages: Simplified paint formulating and reduced fire hazards.

ECONOMICS

Demand outlook for 1962

HPI will see higher demand for products in 1962, according to study of oil companies representing most of domestic refining capacity. Here's the breakdown: Look for gasoline demand to hit 4.3 million bpd, up 2.8 percent over 1961 . . . Kerosine booming, partly because of more jet aircraft, to tune of 430,000 bpd and 7.4 percent increase over 1961 . . . Distillates to go up slightly to 2.0 percent over 1961 for consumption of 1.9 million bpd . . . Heavy fuel oils and residuals up 2.4 percent over 1961, to slightly more than 1.5 million bpd. Remaining categories of LPG, military jet fuels, asphalt, lubes, and petrochemical feedstocks will go up 5.2 percent over 1961 to almost 2 million bpd.

Demand outlook for the '60s

Oil and gas will supply 66 percent of free world's energy by 1970, according to latest study by Chase Manhattan Bank experts. Outlook is optimistic, but big question mark lies in "political invasion of . . . competitive enterprise," says report. The big picture: Total world energy consumption up 50 percent . . . Oil use up 73 percent by '70, while natural gas will double its growth, assuming that transportation problems can be worked out . . . 125 million barrels being gobbled up by free world in next 10 years compared with 75 billion in '50's . . . $140 billion to be spent by industry for research, production and marketing in free world . . . Natural gas to maintain annual growth rate of 5.7 percent.

A less optimistic note appears, however, in statistical estimate that oil's 2.7-percent yearly rate of growth will for first time be below total energy rate of 3.6 percent. A final interesting note in report: In last ten years oil industry actually spent more money than it made. It earned $54 billion, spent $60 billion.

Oil, gas prices to have slight rise

Next 10 years will show only slight increase in cost of crude oil and natural gas in U.S. B. C. Netschert of National Economic Research Associates believes oil and gas prices, assuming government protection stays constant for domestic oil industry, will creep up only few percent in next decade. Advances in technology will tend to block rises in production costs, thus offsetting big increases in exploration. If oil and gas prices do climb, they will eventually reach break-even point of alternate sources of gas and liquids—coal and shale oil.

Forecasts higher research costs

Industry must be prepared to pay higher prices for research. So said Robert C. Gunness, executive vice president, Standard of Indiana, at an Armour Research Foundation dedication. His views: "An adequate price for research is essential to America's growth and safety. Even if military danger passes, as in all common sense it should, we shall remain in world featured by sharp scientific and economic competition.

"Research institutes should be doing larger fraction of

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NITROGEN DIVISION

Dept. G 1-21-1, 40 Rector Street, New York 6, New York

American research than 1.5 percent they are doing today to meet needs of industry and government."

Gunness said research institutes have two great advantages: Specialization and versatility. They can develop technical areas in which they are outstanding authorities and offer wide variety of scientific knowledge, "on tap, ready for use at moment's notice," on which clients can draw.

R & D Engineers gaining in numbers

Engineers in all phases of research and development in U.S. in 1958 numbered 209,000, National Science Foundation reports. This is gain of 51 percent over NSF's 1954 survey with 138,600 figure. Besides engineers, there were 86,100 physical scientists, and 36,000 life scientists in R & D work in 1958. Since 1954, percent increase in numbers of R & D engineers and scientists was almost double proportionate increase in all scientists and engineers. Breakdown of 209,000 total: 177,700 employed by industry, 20,800 by federal government, 9,000 by colleges and universities and 1,500 by other non-profit institutions.

Report reveals HPI growth pattern

Latest Commerce Department report shows figures for 17 top growth products in HPI from 1948 through 1960 —polyethylene coming up with lion's share. Output of polyethylene expanded at an annual average rate of 40 percent since 1948. Report, analyzing industry as a whole, notes that more than 40 percent of products with steepest rate of growth are in chemical industry, and of these, about 50 percent are from HPI. Table below gives HPI breakdown.

Gain for motor fuels

Watch for jump in motor fuel consumption this year. U.S. Bureau of Roads expects a 2.6-percent rise over 1960 and consumption total of 64.9 billion gallons. Motor fuel consumed in highway use is predicted to reach 59.4 billion gallons. This includes 56.7 billion gallons of gasoline and 2.7 billion gallons of special fuels, such as diesel and butane.

Leading state in motor fuel consumption for highway use is California with forecast 5.9 billion gallons, followed by Texas and New York with 3.9 billion gallons each. Other states expected to have high consumption: Pennsylvania, Ohio and Illinois each predicted to top 3 billion gallons. Michigan and New Jersey will each have more than 2 billion gallons. Consumption for these eight states: 47 percent of total.

Big jump for coal by '75

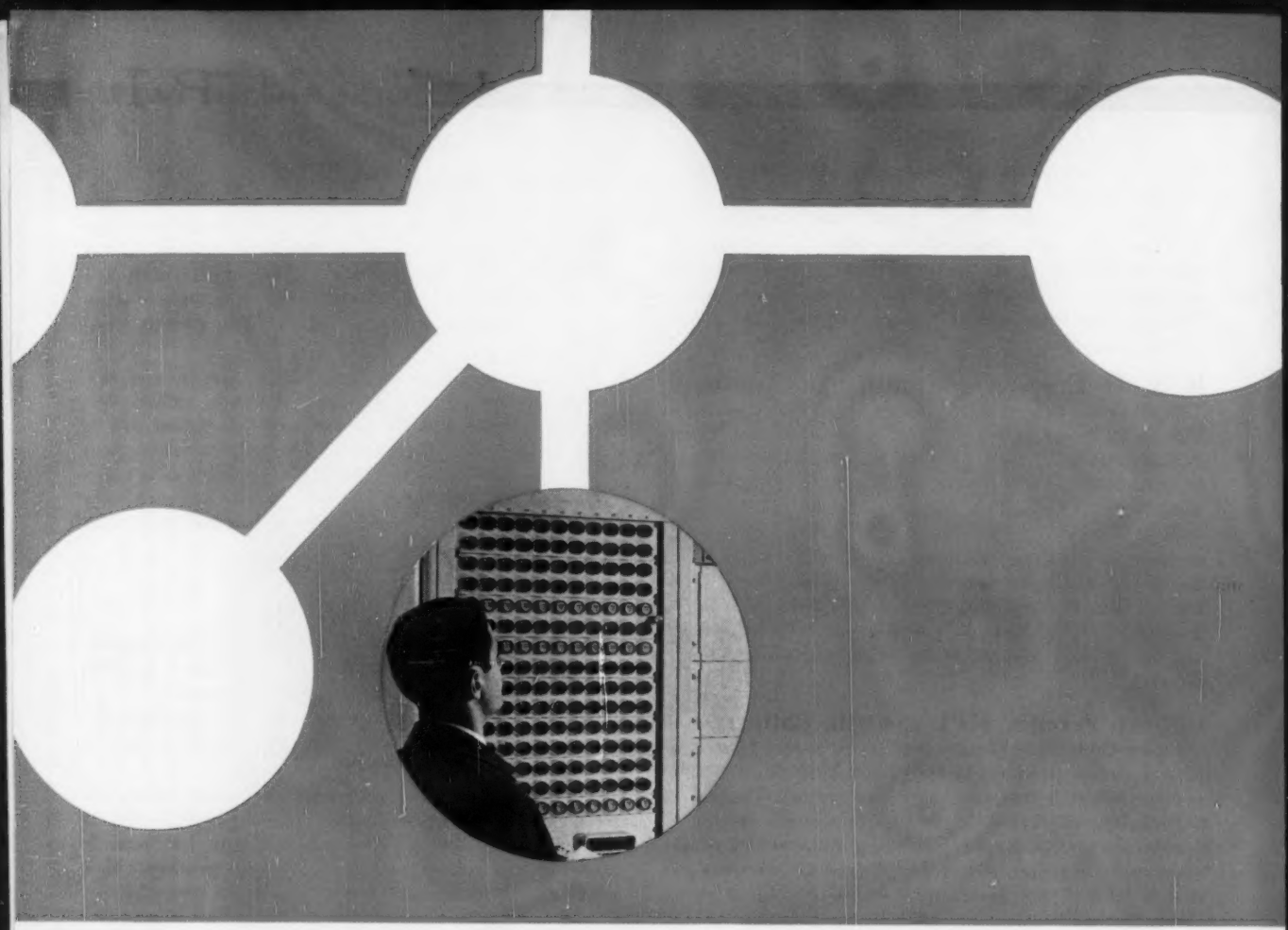
Demand for coal in U.S. should reach 670 million tons per year by 1975, according to Bureau of Mines. In 1960, nation produced approximately 434 million tons.

While coal industry must contend with serious problems for some time, it also can expect larger markets as country's energy needs expand.

Forecast is primarily projection of present trends affecting fuel consumption, including current technological developments, but with no assumptions for possible major changes in technology or other developments that might significantly alter coal's position in years ahead. To develop realistic base for its estimate, Bureau assumed that relationship of certain factors, such as production

Leaders in HPI Products, 1948–60

PRODUCT	Unit	'48	'58	'59	'60
Polyethylene	million lbs.	19	865	1,195	1,337
Synthetic Fibers	million lbs.	75	594	793	856
Helium	million cu. ft.	51	334	477	642
Styrene plastics, resins	million lbs.	165	763	977	1,062
Polyvinyl plastics, resins	million lbs.	218	869	1,166	1,190
Xylenes	million gals.	61	200	241	282
All plastics, resins	million lbs.	1,485	4,659	6,021	6,140
Ethylene glycol	thousand lbs.	367	1,145	1,215	1,299
Anhydrous ammonia	thousand tons	1,375	3,879	4,520	4,812
Perchlorethylene	million lbs.	68	187	203	209
Pentaerithritol	million lbs.	21	52	64	64
Synthetic rubbers	thousand l.t.	488	1,055	1,380	1,436
Butadiene	million gals.	661	1,465	1,816	1,883
Formaldehyde	million lbs.	617	1,358	1,750	1,698
Urea & melamine resins	million lbs.	149	349	424	399
Phenol	million lbs.	297	506	692	773
Benzene	million gals.	184	287	347	456



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Temperatures, pressures, flows, levels, closures, in fact any input that can be represented by DC voltages as low as 10 millivolts full scale can be monitored by the Hagan AIM (Alarm Indicating Monitor) with an accuracy of plus or minus 0.1% full scale.

Fast and reliable, the Hagan AIM is compact—for example, the readout and alarm panel for 200 alarm points will fit into a 19″ x 47¼″ panel area. Combining all alarm functions in one instrument, AIM can be set for high or low alarm points, or both. Seconds after a monitored variable goes out of bounds, AIM energizes the alarm light and sounds a warning horn. The horn can be shut off, but the light stays lit until the condition is corrected. AIM safeguards both equipment and process from the shattering damage that a single runaway variable can produce. Now *one* man can watchdog a complete process line, taking corrective action before damage is done.

AIM is one component of the complete Hagan line of process controls, which include primary elements, transducers, controllers, recorders and final control elements. Designed for use with existing installations or for complete new systems, the Hagan line can save you money in terms of more accurate control with minimum adjustment and maintenance. For information, write or phone HAGAN CHEMICALS AND CONTROLS, INC., Hagan Center, Pittsburgh 30, Pa.

HAGAN

and consumption efficiencies and prices for different fuels, would remain relatively stable during next 15 years.

What is coal's role as HPI competitor?

Petroleum industry has a firm grip on most HPI products in which coal used to have big interest. But question arises, "Are there still some coal-tar products and chemicals which we can't get from petroleum?" Answer is yes, according to study by F. L. Byrom, president of Koppers, presented in October before Southern Research Institute, and here's picture as he sees it: Electrode pitch for making electrodes for aluminum industry, water-proofing, corrosion-protective pitch, creosote and coal-tar wood preservatives for marine piling have no substitutes of anywhere near equal value from alternative sources.

Creosote-coal-tar solutions still remain outstanding preservative for marine piling. Coal tar pitch is still outstanding corrosion-protective and water-proofing material for steel work, pipelines, foundations under hydrostatic pressure, tunnels, marine drydocks, and for flat roofs. We have no adequate substitute for coal tar pitch as binder for electrodes for aluminum industry and commercial carbon industry. Requirements for these products alone will continue to keep coal tar industry one of extreme national importance.

Recovery and utilization of more complex aromatic chemical constituents of coal tar has been barely explored and remains as great challenge to tar industry. Such potentially useful compounds as chrysene, pyrene, acridine, fluoranthene, acenaphthene, fluorene, and phenanthrene, challenge ingenuity of coal tar chemist. Success for such efforts would open whole new fields of raw materials for synthesis of complex dyes and medicinals.

There is no other source available which provides these chemical raw materials in as readily available form. Physical processes newly developed for other industries may offer economical means for recovering these high boiling and high melting chemicals. This path of coal tar research lies open, but remains as yet unexplored.

From competitive standpoint, what is future of coal chemicals? First, both basic raw material sources, coal tar and crude petroleum, from which aromatic chemicals can be recovered, have basic fuel values. Because of its greater density, its higher carbon-to-hydrogen ratio, its higher aromaticity, and its generally lower sulfur content, coal tar commands premium over petroleum as heavy fuel in steel industry.

Second, recovery of many chemicals from tar is more simple than aromatization, extraction, and purification in petroleum industry. Cost of recovery of aromatics in petroleum industry will never go so low as to eliminate their recovery by tar industry. Coal tar aromatics will always be in strong competitive position with respect to petroleum-derived aromatics. This means that tar industry will continue to be able to market its products.

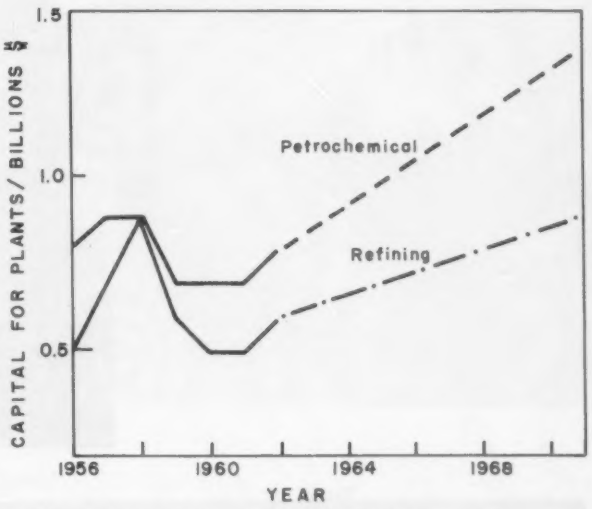
Third, uses for coal tar pitch are growing rapidly, and we shall see greater pressure for tar to move out of fuel uses, ultimately even from premium fuel uses, to be converted into pitches for aluminum and other industries. This should provide greater availability of coal chemicals.

Fourth, in highly complex molecules, coal chemicals industry offers wide range of as yet unexploited raw materials.

Other potential routes to production of chemicals directly from coal include fluorination, chlorination, or oxidation. So far, no commercial success has been achieved using these routes.

Who'll win in refining, petrochemicals?

Petroleum refining and petrochemicals are becoming more alike with each passing year, according to study by Kellogs' H. G. McGrath and L. R. Hill at Chicago API meeting, Refining Division. The big picture as seen by authors: Chemistry and catalysis are now prominent in



both refining and petrochemicals. Rapidly growing petrochemicals account for about one third of total chemical production. For past few years, annual investment in new plants and facilities in petrochemical industry has been greater than that for refining, and this condition is expected to continue. Total current assets of petrochemical industry are valued at $6 billion.

Key refining development in last 10-15 years: Widespread synthesis of aromatics for gasoline because of sound catalytic chemistry and processes, and pressures from automobile industry. Result was big octane scramble of '50's.

INTERNATIONAL

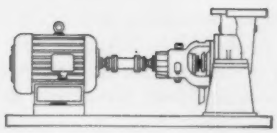
Soviets add tankers to expand exports

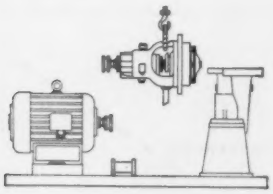
Soviet Union is making efforts to capture larger portion of world oil trade, according to U.S. Bureau of Mines.

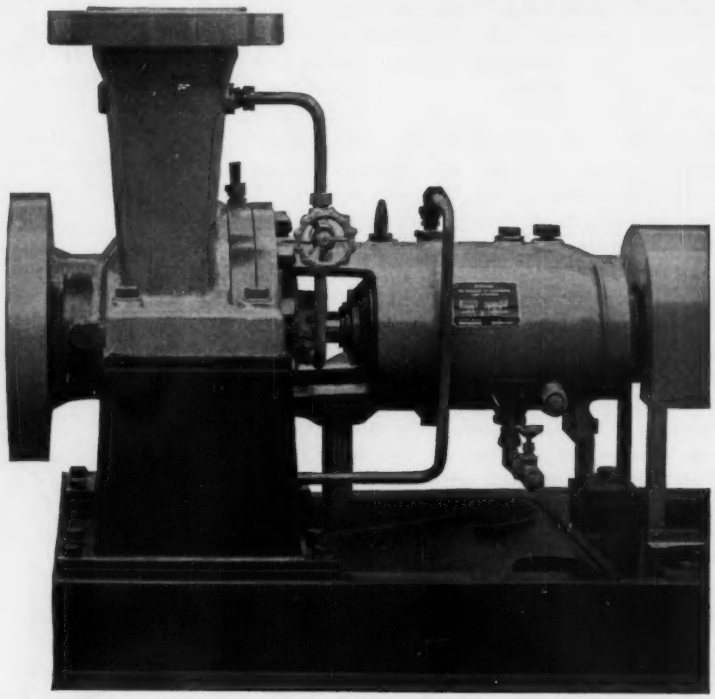
In past 10 years U.S.S.R., which is now world's second largest crude oil producer, has increased its tanker

for more about what's happening in HPI, turn to Page 379

KSB







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for handling hydrocarbons such as crude oil and its many distillates and derivatives at temperatures ranging from –165 to 850 F = –110 to 450 C.
These pumps are available in 22 sizes designed to ensure efficient performance at all operating points usually encountered, and special attention is paid to optimum NPSH values.
The great variety of operating conditions and the continuity of the production processes in refineries and the petrochemical industry are met by special design features that include
ready access to the interior of the pump for inspections and overhauls without having to lift the volute and the prime mover off the bedplate,
the possibility of interchanging any type of shaft seal without the efficiency being impaired and without the necessity of modifying the standing parts,
a reduction in the number of spare parts that have to be stocked by application of the unit construction principle so that the components of many sizes are identical.

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**Available in tank cars,
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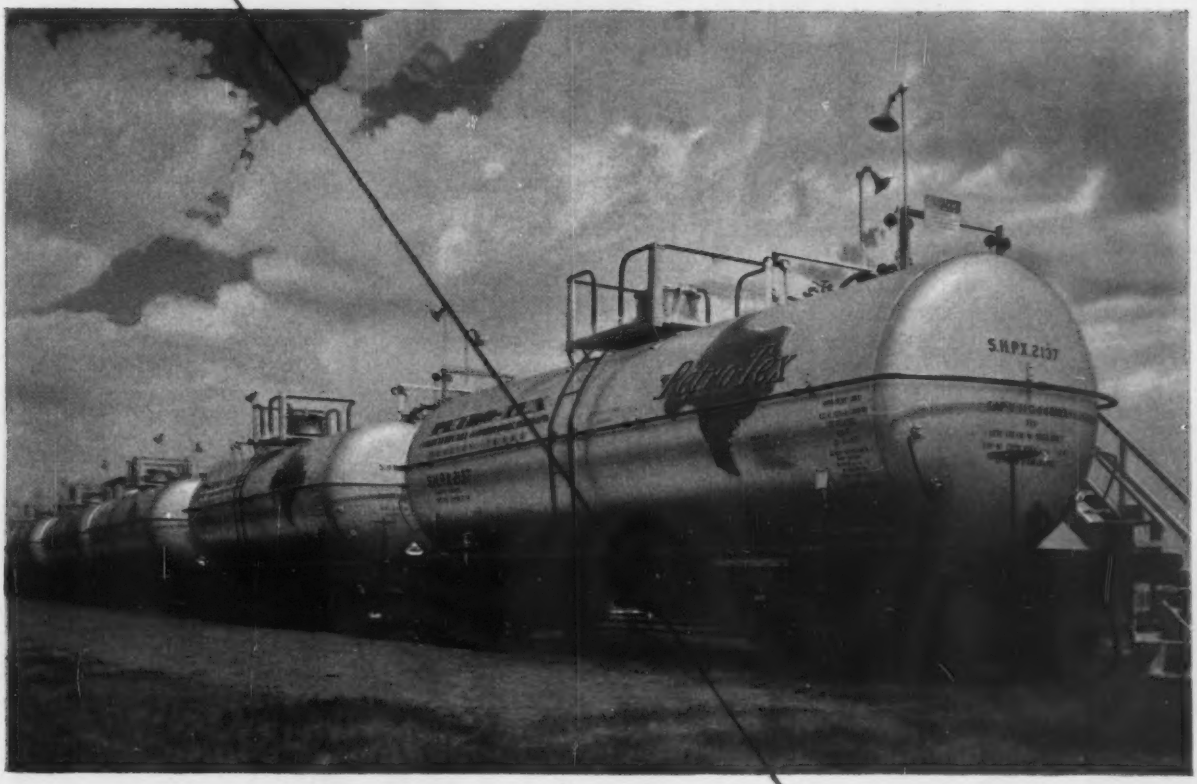

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BUTENE-1 Highly reactive high purity alpha-olefin with low moisture.

BUTENE-2 Beta unsaturated high purity olefin, and virtually free of Butene-1 isomer.

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TRIISOBUTYLENE Clear water-white mixture of 2,2,4,6,6-Pentamethyl-heptene-3 and 2-Neopentyl-4,4-dimethyl pentene-1.

ISOBUTYLENE Major continuous production of high purity material.

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RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.

In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.

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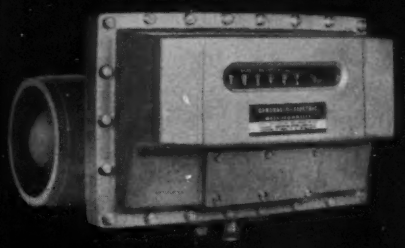
INSTRUMENT DEPARTMENT

GENERAL ELECTRIC



Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity, flow rate. 13 standard ranges now available.

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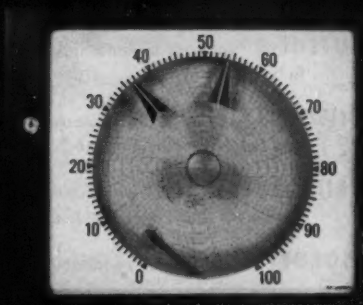
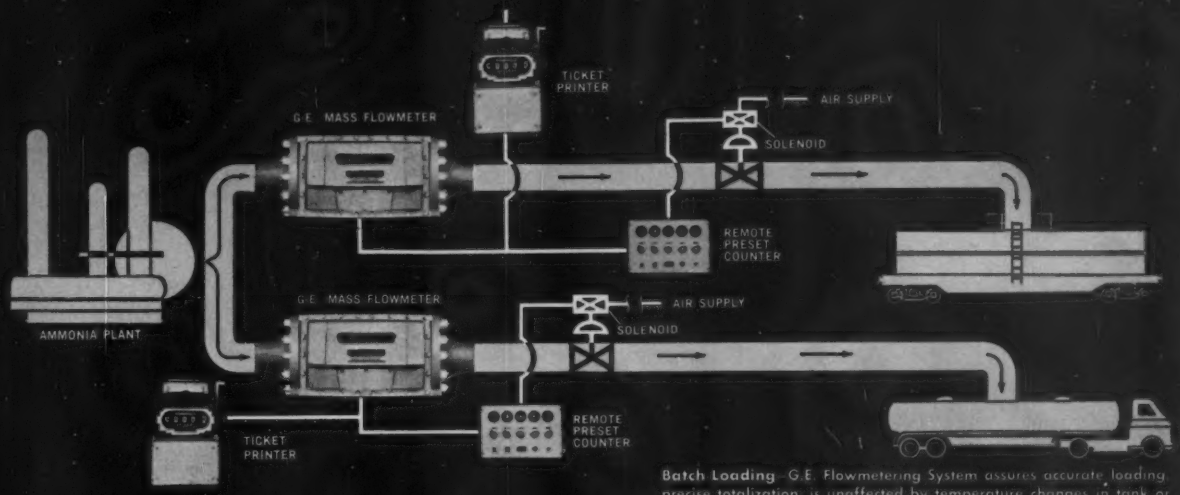
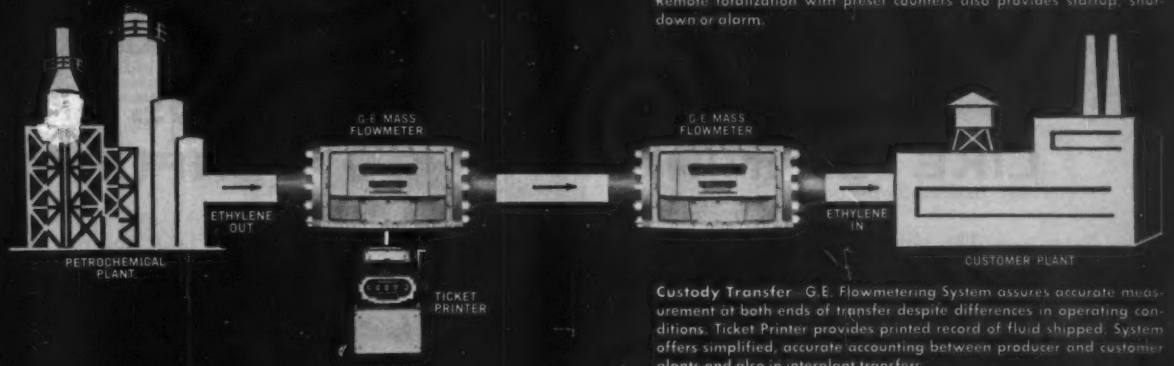


General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen—strip or round-chart models.

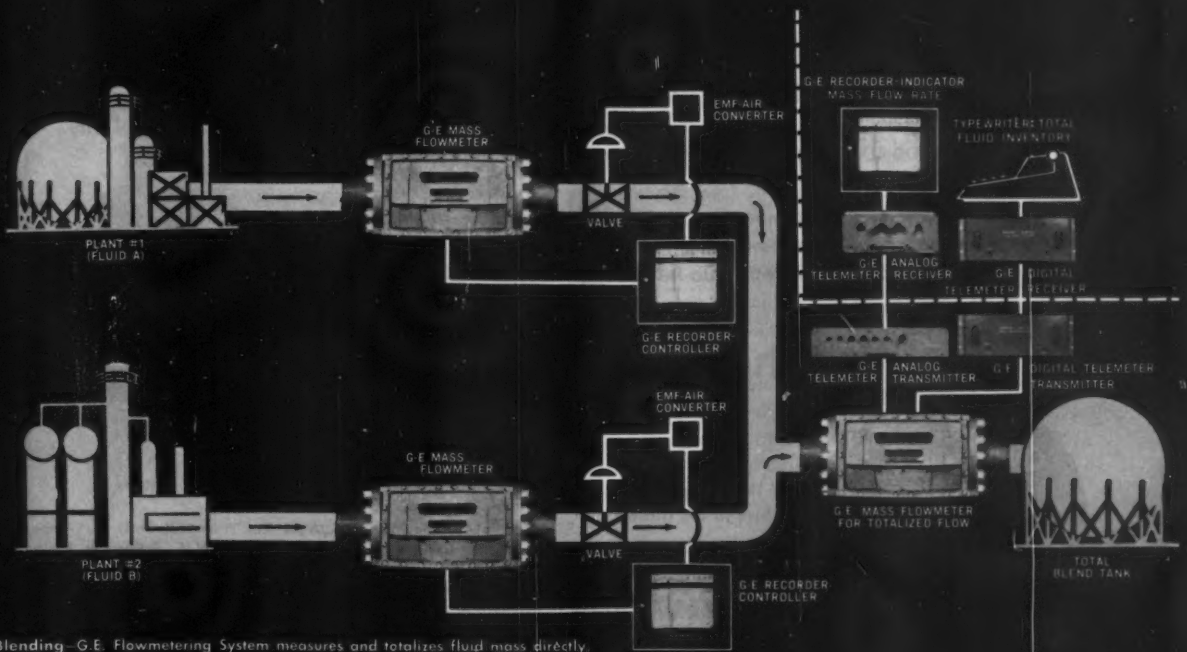


Batch Loading—G.E. Flowmetering System assures accurate loading, precise totalization, is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration change. Remote totalization with preset counters also provides startup, shutdown or alarm.

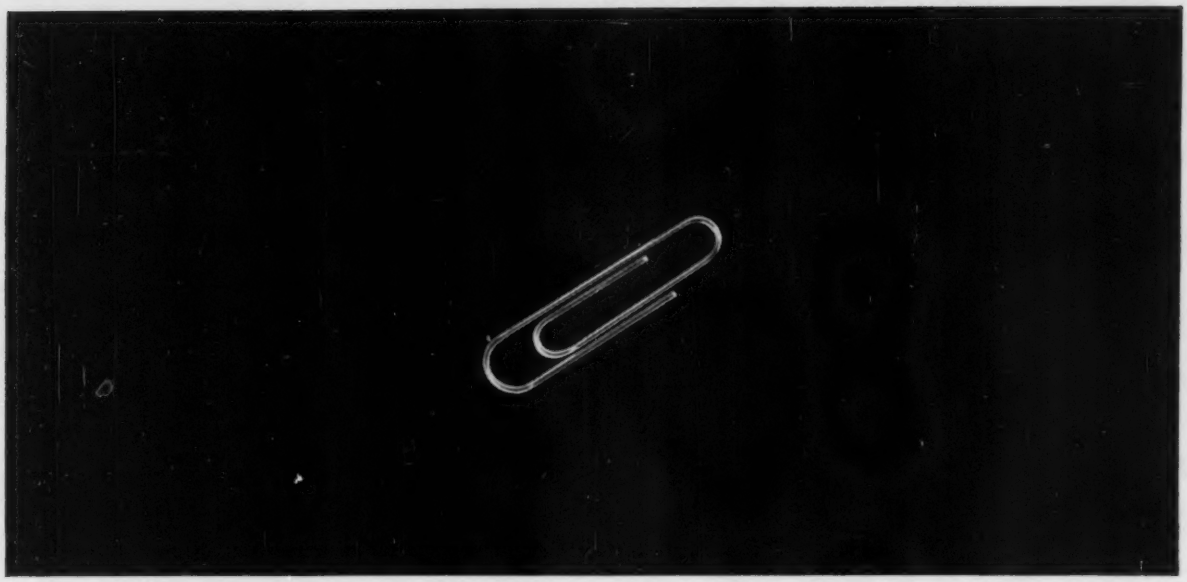


Custody Transfer—G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC



Fluid Blending—G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G-E Telemetering. Typical blends are refrigerants, solvents and special naphthas.



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Lubes: Undesirable aromatic and olefinic components are selectively dissolved and separated from the desirable paraffins and naphthenes.

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Butadiene: In the purification of butadiene, furfural alters relative volatilities of C_4 hydrocarbons. This permits easy fractionation of compounds differing in degree of unsaturation to give good yields of high purity butadiene.

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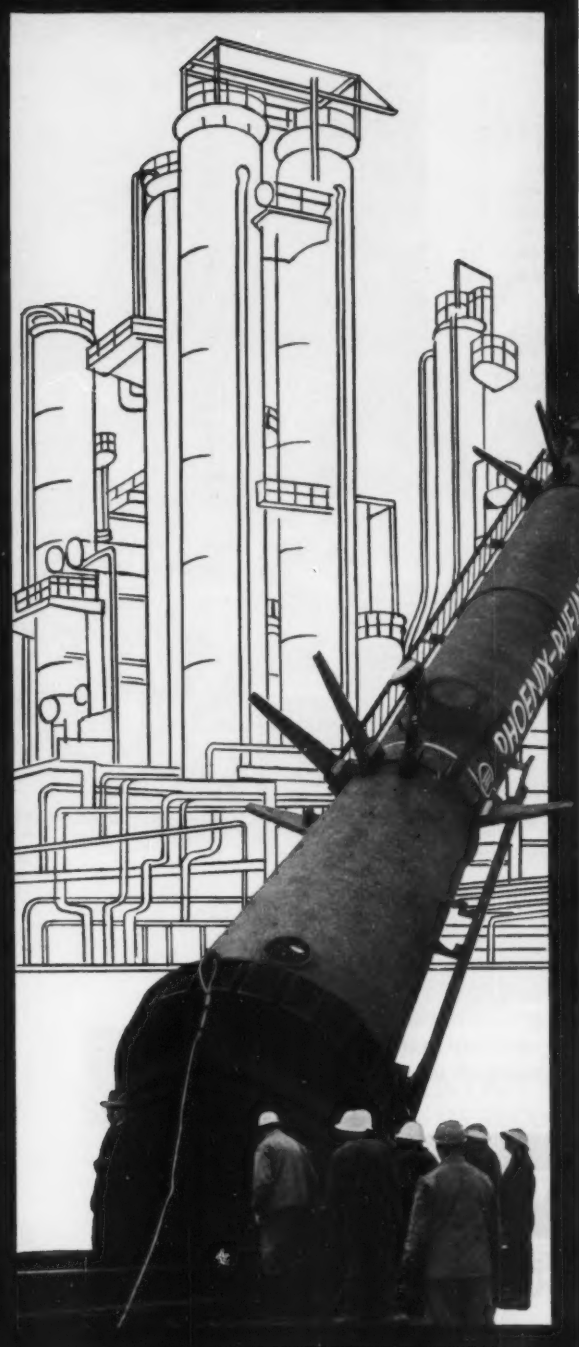

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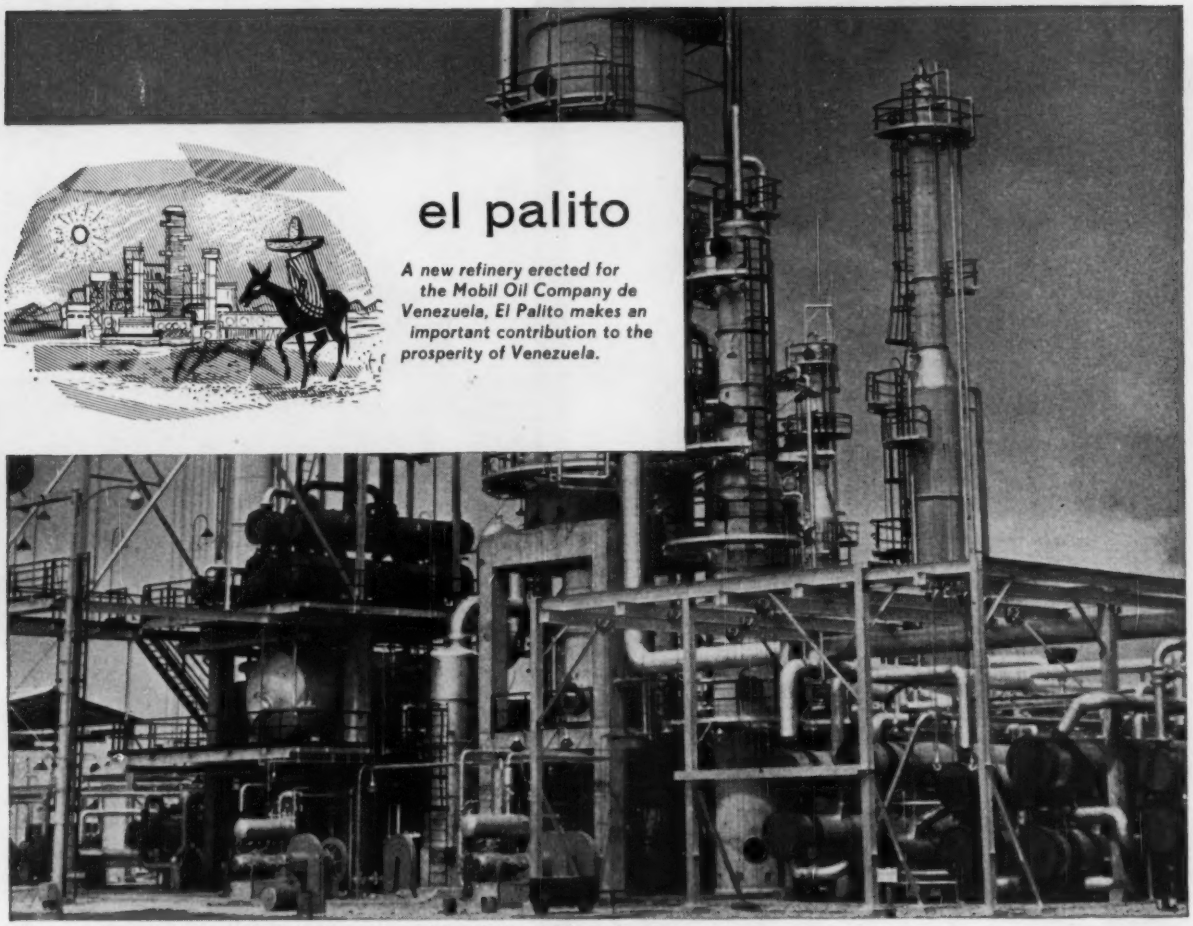

(Illustrated: Crude Distillation Unit and the Depropanizer and Straight Run Stabiliser columns).

insulation assignment at El Palito

A growing number of refinery insulation engineers are turning to NEWALLS (Regd Brand) NEWTHERM Calcium Silicate Insulation—the insulation with qualities of particular significance in this field. Strong, yet of very light weight—moisture resistant and easily applied, NEWTHERM was specified for much of the more important process plant at El Palito.

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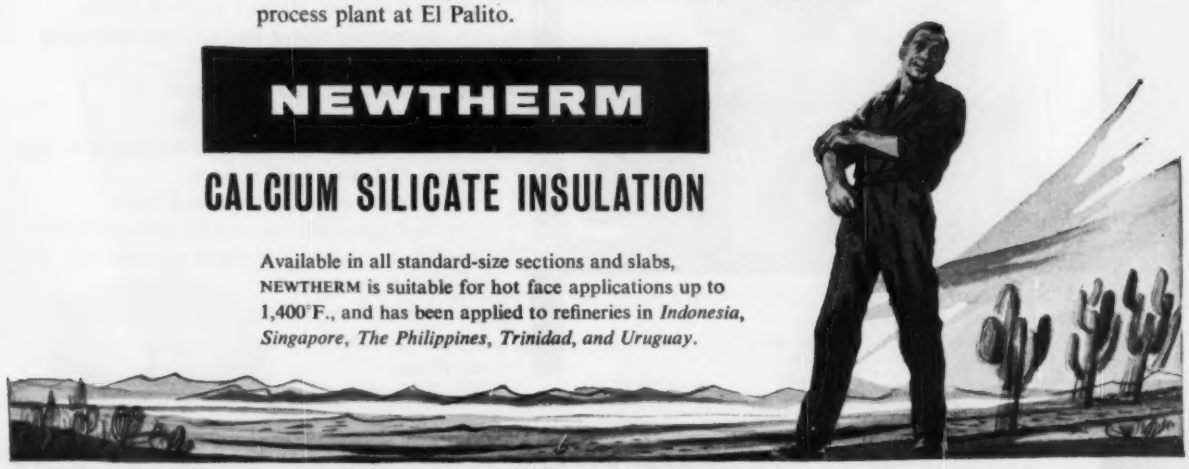

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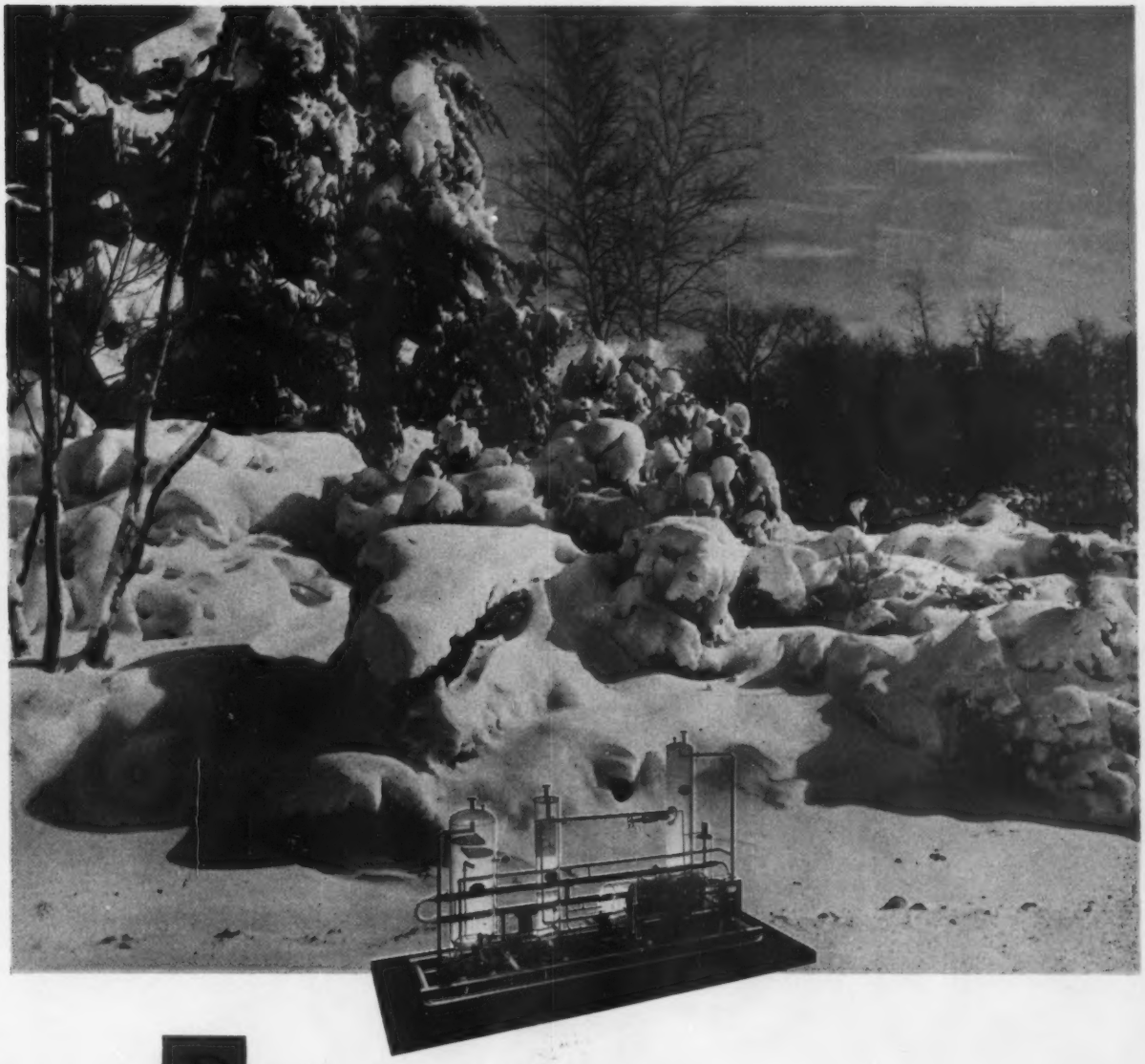

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The **exclusive** Parkersburg "T-Bone" cold separation vessel combines the good points of vertical and horizontal vessels. The gas is dehydrated to better than pipeline specifications and a greater volume of salable condensate is recovered than is possible with conventional separation. As a matter of fact, the additional hydrocarbon recovery will usually pay out the unit in a short time.

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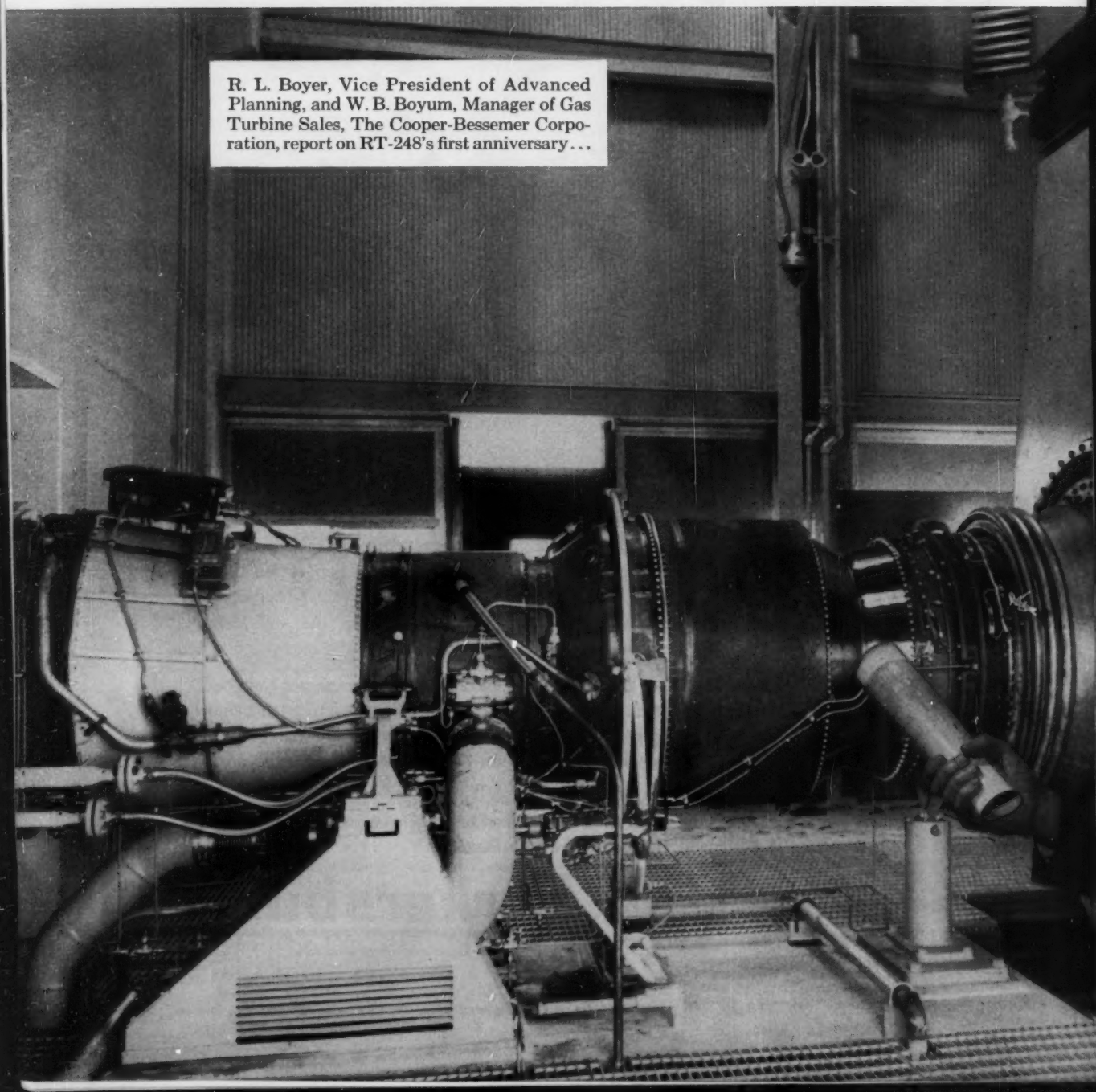
Division of Parkersburg-Aetna Corp.

HOUSTON • COFFEYVILLE • PARKERSBURG

*PARKERSBURG Trademark Patented

For more data on advertised products, use cards, last page.

First anniversary report on world's first jet-powered gas turbine



R. L. Boyer, Vice President of Advanced Planning, and W. B. Boyum, Manager of Gas Turbine Sales, The Cooper-Bessemer Corporation, report on RT-248's first anniversary...

The Cooper-Bessemer RT-248 gas turbine shown below started operation on October 31, 1960, at Columbia Gulf Transmission's Clementsville (Kentucky) compressor station of the Columbia Gas System. Here's what it proved after the first year in service:

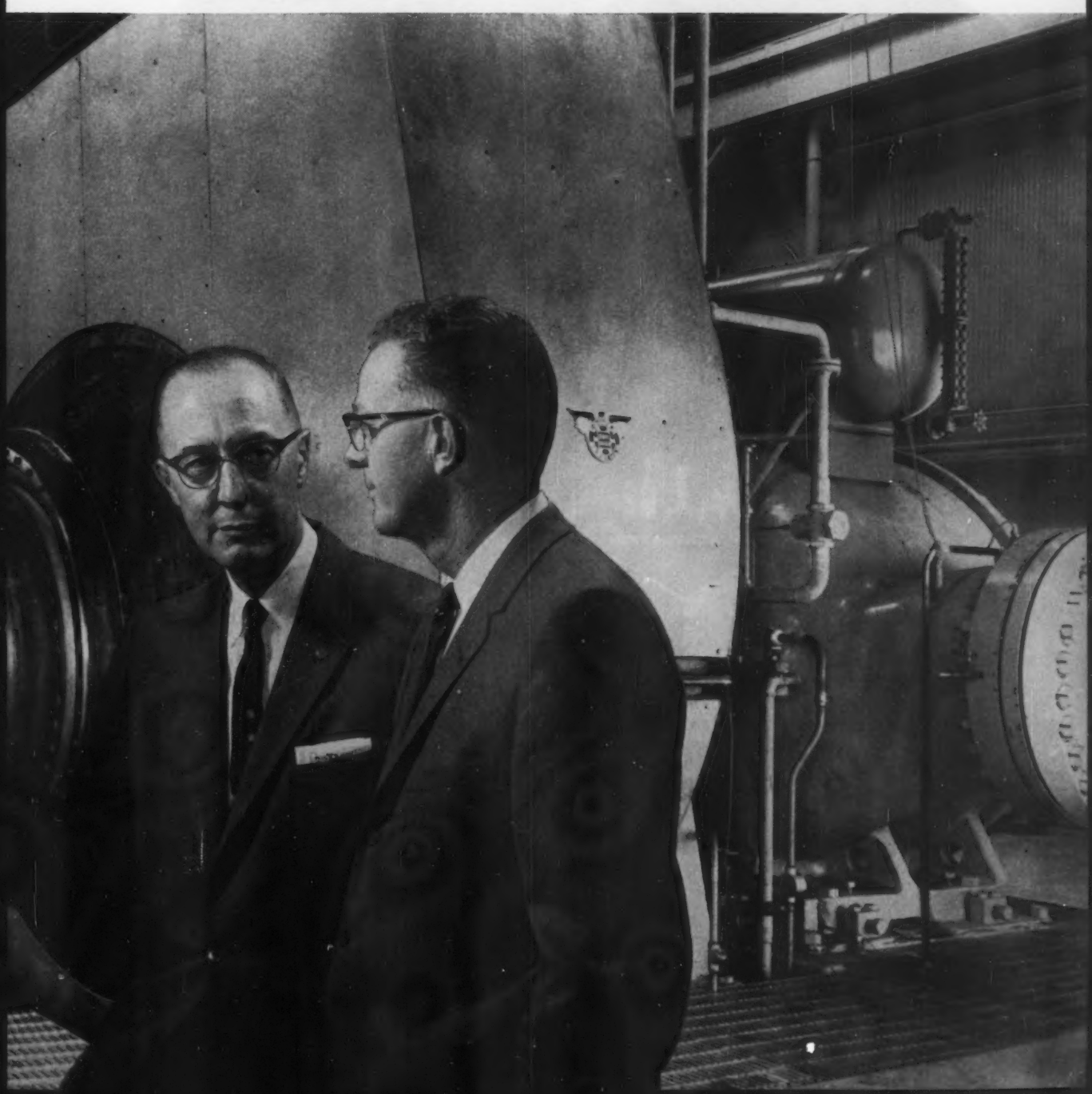
• Unparalleled overall economy of operation, as expected. • Exceptional reliability and availability, proven by 6500 hours of heavy-duty service with average load in excess of its 10,500 hp rating. • Simplicity and ease of control. Since June 20 has operated remotely from Nashville. • High efficiency (25%) without costly, bulky regeneration equipment. • Lower overhaul and downtime expense than with other comparable prime movers. Unit exchange concept with factory reconditioning of "jet" simplifies maintenance.

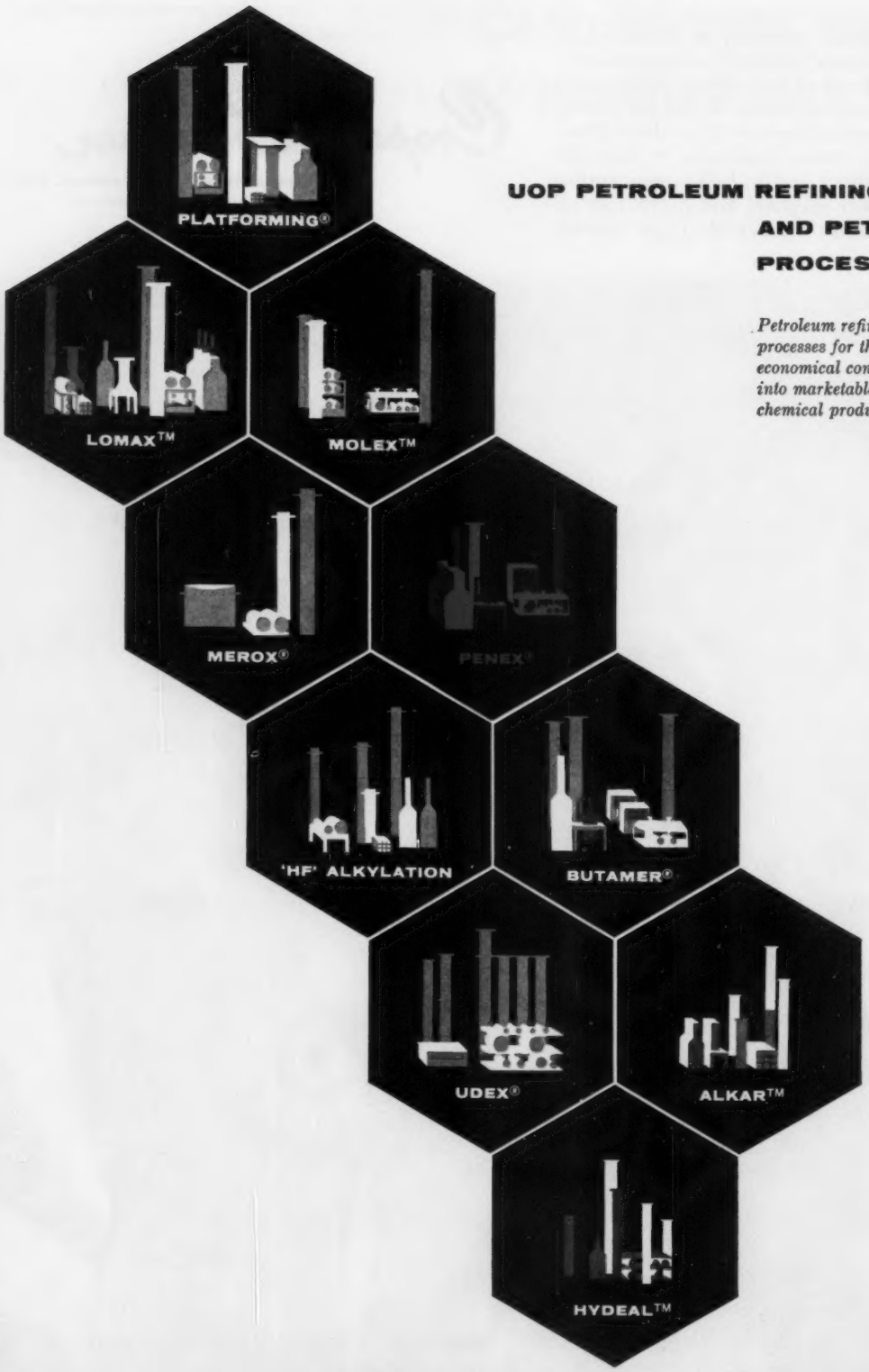
The RT-248 is a joint development of Cooper-Bessemer and Pratt & Whitney Aircraft. For further information on this and other C-B gas turbines, from 340 to 15,000 bhp, for all power applications, contact our nearest office.

Cooper Bessemer

GENERAL OFFICES: MOUNT VERNON, OHIO

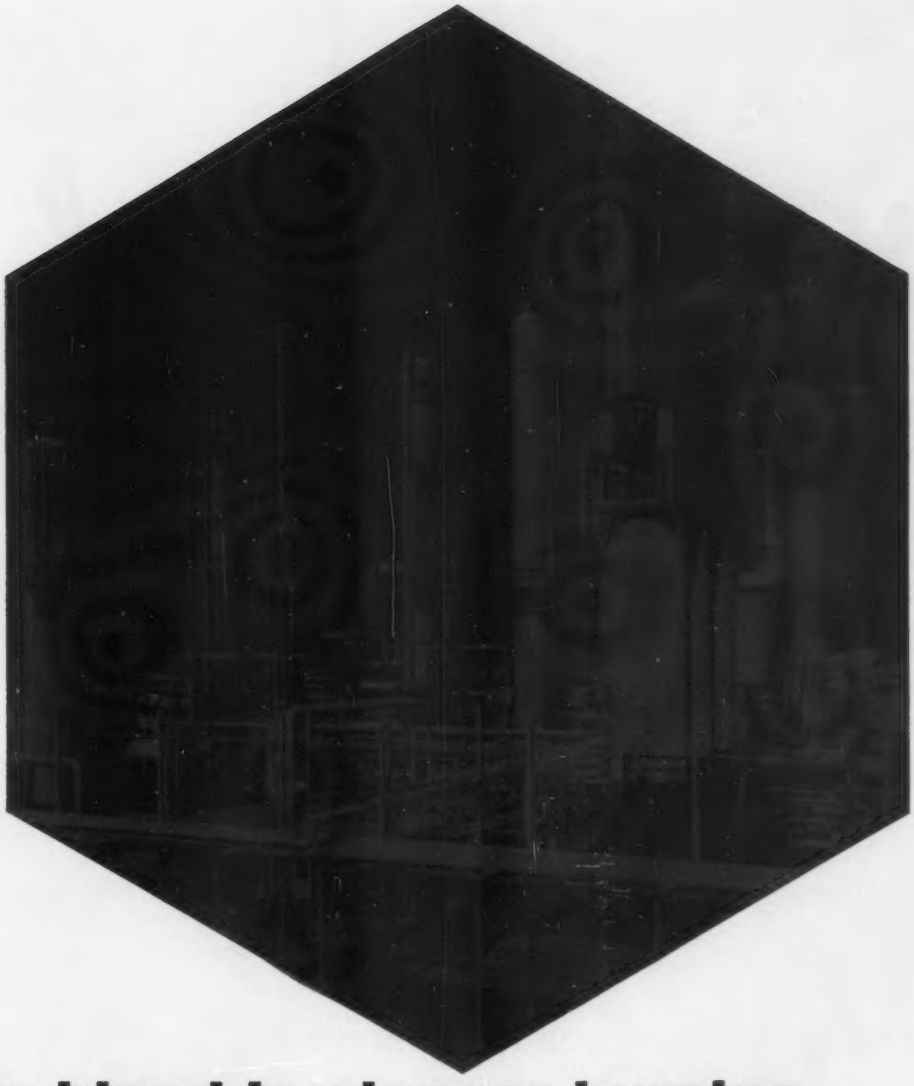
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINES: GAS - DIESEL - DUAL-FUEL
JET-POWERED GAS TURBINES





UOP PETROLEUM REFINING AND PETROCHEMICAL PROCESSES

Petroleum refining and petrochemical processes for the efficient and economical conversion of petroleum into marketable fuel and chemical products.



now blend in cleaner burning, highest octane components

"HF" ALKYLATION gives refiners a blending component that combines the ideal qualities of a clean burning fuel that gives smooth engine performance with high octane number. Often refiners find themselves pushed into an economic corner in producing gasolines that burn clean, efficiently, and give maximum power. "HF" Alkylation is a catalytic process that produces an isoparaffinic fuel component that burns with a minimum of carbon deposit . . . greatly reduces surface ignition and consequent rumble . . . and is ideally suited to the auto engine of today.

The UOP-developed "HF" Alkylation process combines olefins such as propylenes, butylenes and amylenes with an isoparaffin, usually isobutane. The product formed, alkylate, is a mixture of branched chain hydrocarbons of higher molecular weight. It is widely used in producing high octane aviation gasoline, as well as an anti-rumble component in motor fuel.

UOP also offers Sulfuric Acid Alkylation for special situations where the refiner's economic, supply, or production situation may give this process a greater profit potential.

With more than a score of different processes UOP can offer you the most profitable method for the processing of petroleum. Let UOP engineers evaluate your processing needs now.

WHERE RESEARCH IS PLANNED
WITH PROGRESS IN MIND

UOP®

UNIVERSAL OIL PRODUCTS COMPANY
30 Algonquin Road, Des Plaines, Illinois, U.S.A.

For more data on advertised products, use cards, last page.

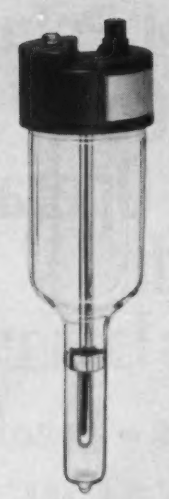
TEST OF OIL-FIRED SNOW REMOVAL UNIT CAPABLE OF MELTING 75 TONS PER HOUR

"The task of expanding our industry's market must be undertaken by individual companies. Aggressive efforts are required by each of us if the challenge is to be met. We have research and development facilities and people second to none. Let's use them to develop newer and larger markets for oil products."

—M. J. Rathbone, President

Standard Oil Company (New Jersey)

(WHOSE PRINCIPAL U. S. OPERATING AFFILIATE IS HUMBLE OIL & REFINING COMPANY)



...with new rugged 7" reference and 3¾" glass electrodes...

new industrial pH system stresses reliability, flexibility

Beckman, world leader in pH instrumentation, introduces the all-new Model J pH System: compact transistorized analyzer, short, rugged electrodes, and accessory mounting assemblies. Here's continuous analysis equipment which provides reliability, flexibility, and convenience never before possible in industrial applications.

Check these Model J features, then see your Beckman Sales Engineer or Recorder Company Salesman for complete details, or write for Data File 25-11-06.

READOUT FLEXIBILITY. Available with both ma and mv output for use with any potentiometric or current recorders and controllers–or, with mv output only–recorder scale may be expanded to any 2 pH span full-scale. High or low alarm feature may be added.

SOLID-STATE ELECTRONICS. Assures reliability and saves long-term maintenance costs.

QUICK-DISCONNECT ELECTRODES. Short, rugged glass and reference electrodes feature capscrew for quick connect-disconnect of spade lug connectors. Speeds installation and replacement of electrodes.

DRIFT-FREE OPERATION. AC chopper amplification provides stability of 0.01 pH/24 hrs. over a −20°F to +122°F ambient temperature range.

HIGH ACCURACY AND SENSITIVITY. Output accuracy and meter sensitivity is ±0.02pH for full 0-14 pH or 0-±1400 mv range.

SIMPLIFIED MAINTENANCE. Plug-in components and circuits, rail-mounted analyzer chassis assure ease of maintenance, reduce downtime.

MINIMUM PANEL SPACE. Compact analyzer complements miniature current recorders, mounts in 6″x6″ cutout.

ACCESSORIES FOR YOUR REQUIREMENTS. Variety of flow chambers and immersion and submersion units adapt Model J System to your present and future plant applications.

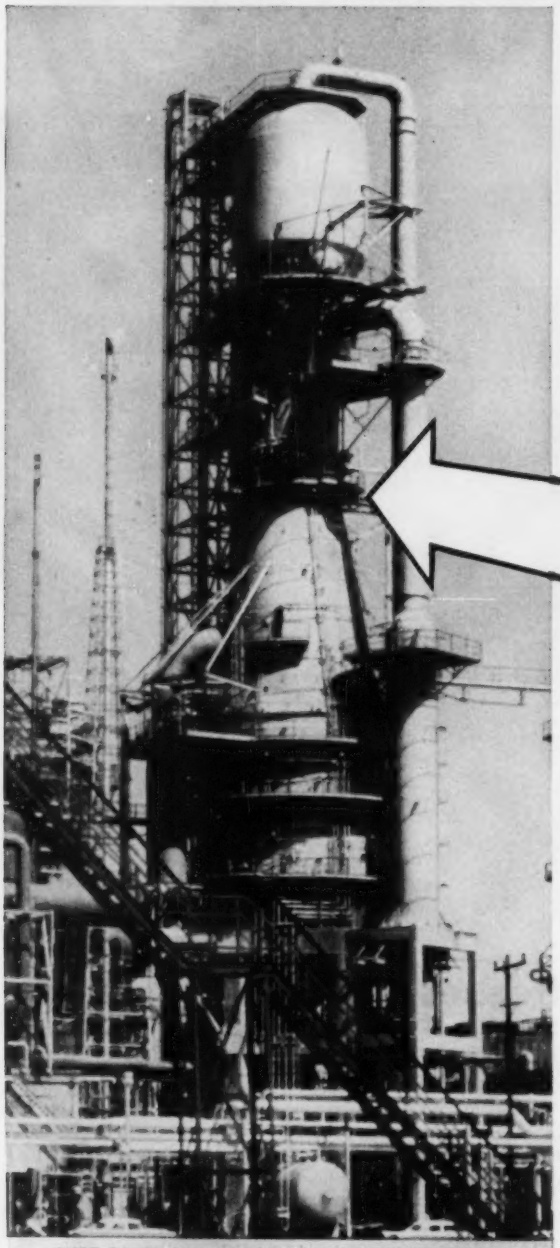
Beckman INSTRUMENTS, INC.

SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION

Fullerton, Calif.

VISIT OUR BOOTH AT THE CHEM SHOW

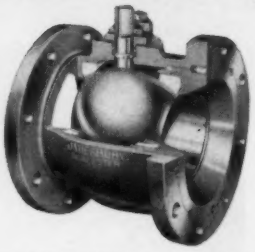
At *CRITICAL* Valve Control Points



...You Get Dependable Operation with

jamesbury "Double-Seal"™ BALL VALVES*

*PATENTED.



WIDE RANGE OF SIZES:

Screwed end ¼" through 3".

Flanged 150# series ½" through 12" — 300# ½" through 8".

Larger sizes on request.

VARIETY OF MATERIALS:

Valves in 303 and 316 Stainless Steel, Alloy 20, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Interchangeable seats and seals in Teflon, Teflon compounds, Nylon, Buna-N, Neoprene, Hypalon and natural rubbers. Type DZ: Ductile Iron and Carbon Steel, Standard. Other materials on request.

FIRE SAFE VALVING IN REFINERIES

The Jamesbury "Double-Seal" FIRE SAFE Ball Valve (Type DZ) has been accepted for use in the hydrocarbon industry because of its outstanding performance. In the event of fire – and the loss of the valve's soft seats, secondary metal seats provide effective shut-off of the fluid flow.

It stands to reason that a valve that performs outstandingly under adverse conditions can be relied on to give trouble-free performance under less severe conditions. That has been one of the big reasons, at least, for the success of Jamesbury "Double-Seal" Ball Valves. Proved dependable at *critical* valve control points, these valves have gone into industrial plants everywhere to control nearly all types of media flow.

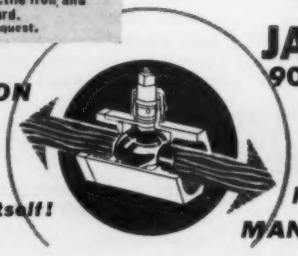
There are many exclusive features about the Jamesbury "Double-Seal" Ball Valve which contribute to its excellent performance record. For example, there's Jamesbury's patented lip seal; there are no internal springs; you get leak-tight stem seals; operators are mounted integral with the valve. For further information about Jamesbury "Double-Seal" Ball Valves, contact your nearest stocking distributor – or write us direct.

Ask For Jamesbury Fluid Services Guide

JAMESBURY CORP.
90 New Street, Worcester, Mass.
DISTRIBUTORS IN PRINCIPAL CITIES

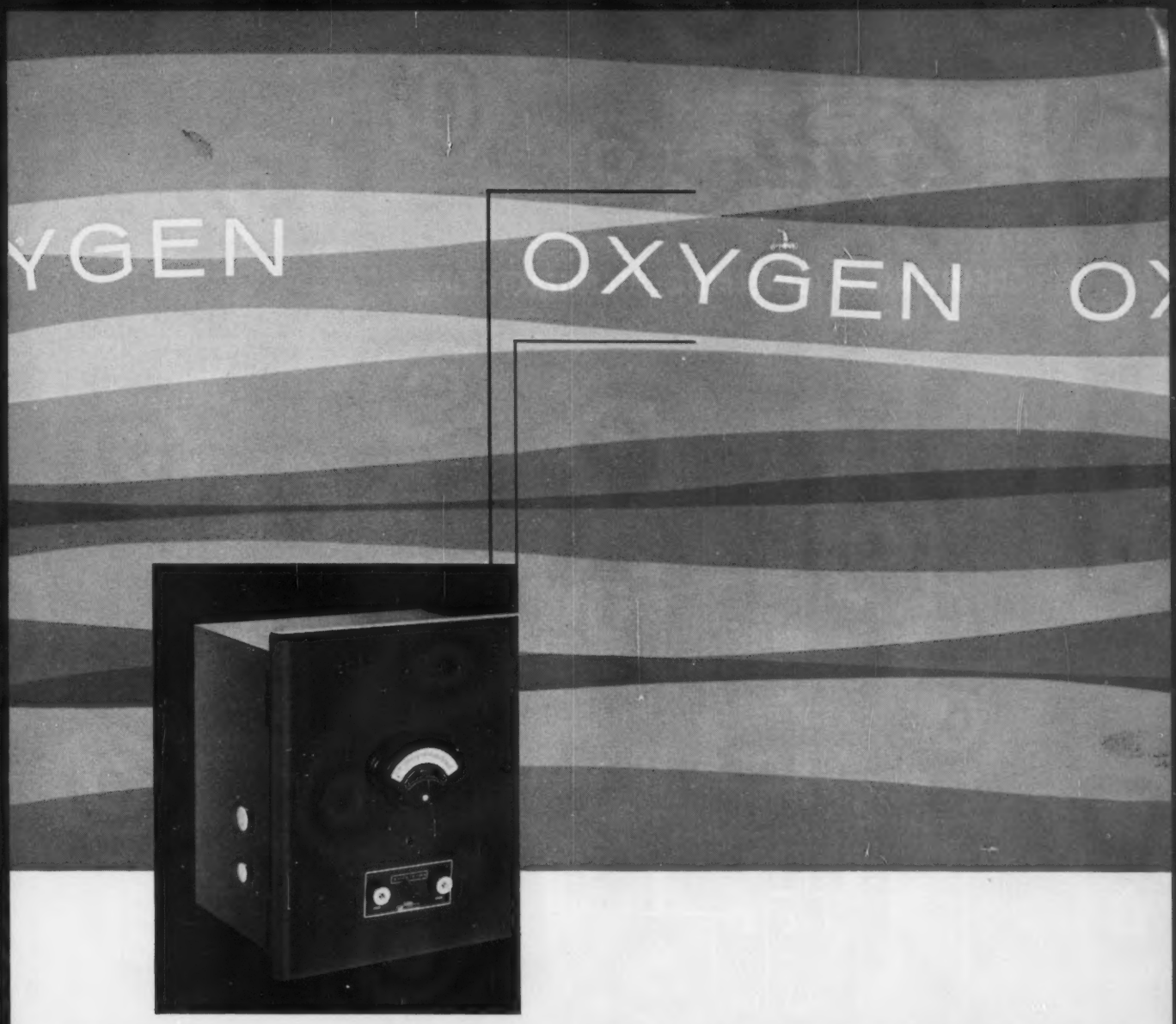
QUARTER TURN OPERATION
HIGH FLOW CAPACITY
ZERO LEAKAGE

As Versatile As Industry Itself!



NO LUBRICATION REQUIRED
MINIMUM MAINTENANCE
MANUAL OR POWER OPERATION

174-I ©Jamesbury Corp. 1961



Wherever continuous oxygen measurement must be accurate...Beckman has the right answer!

Beckman has the instrument that's made to order for your oxygen measurement application. For Beckman has the most complete line of Oxygen Analyzers from which to choose. Measure 0_2 in ranges from parts per million to 100%–with sample handling equipment to meet your most exacting requirements.

Your Beckman Sales Engineer has the answers to your questions on process Oxygen Analyzers. Contact him for complete details, or write for Data File 25-11-08

VISIT OUR BOOTH AT THE CHEM SHOW

MODEL F-3 operates on a paramagnetic principle found only in Beckman® Oxygen Analyzers. Assures fast response, great sensitivity, and simple operation. And the F-3 has dual ranges that are directly linear. Read oxygen concentration from a self-contained meter or a standard potentiometric recorder. The Model F-3 is ideal for wide ranges of analyses–from 0-1% to 0-100%–and suppressed ranges are available, too.

MODEL G-2 also utilizes the paramagnetic principle of operation. Supplied with potentiometric recorder modified to provide automatic instrument zeroing for critical analyses. The Model G-2 is ideal for narrow and highly suppressed ranges–0-1000 ppm to 99-100%.

MODEL 80 TRACE OXYGEN ANALYZER operates on the electrolytic cell principle. This dual range instrument provides highly accurate linear measurement in the parts per million ranges. The Model 80 is particularly suited for monitoring gases in which oxygen content must be extremely low–from 0-5 to 0-500 ppm.

ALSO AVAILABLE AND READY TO SERVE . . . a complete line of portable laboratory oxygen analyzers.

Beckman INSTRUMENTS, INC.

SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION

Fullerton, California

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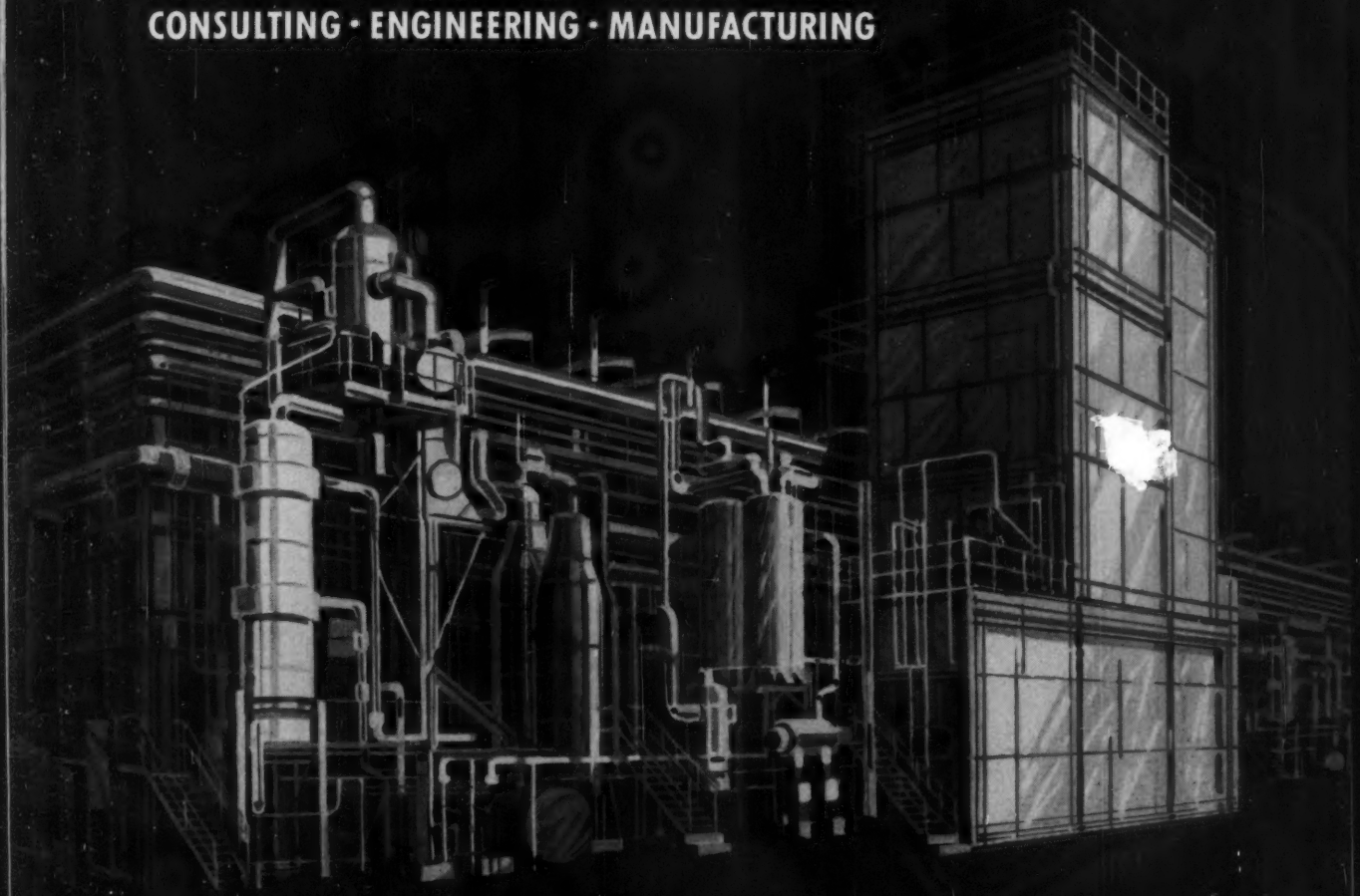
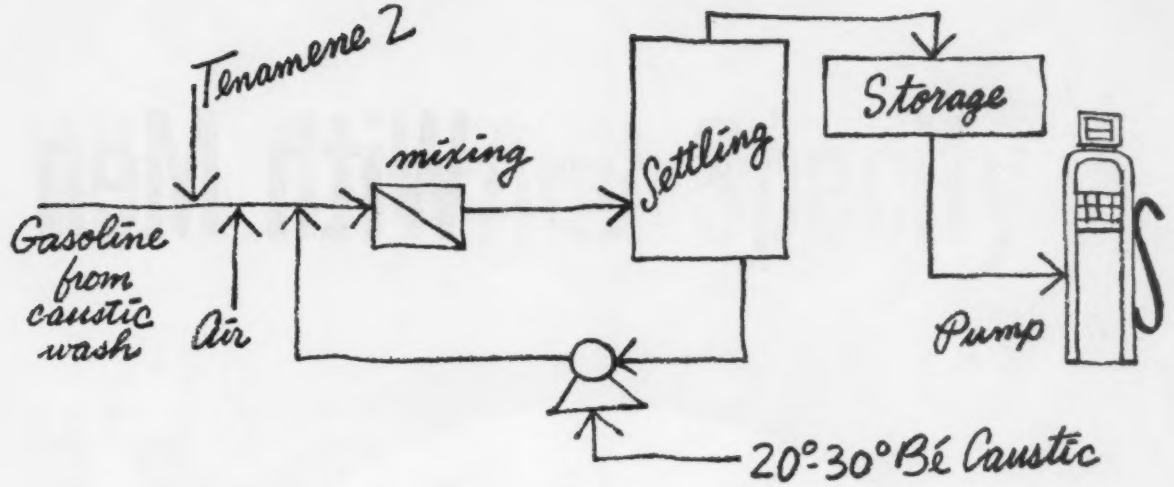


Plants for the decomposition of cracking gases or other gas-mixtures occuring in the chemical industry, in particular for the production of pure hydrogen, ammonia synthesis gas, methanol synthesis gas, purest ethylene, pure methane, pure propylene, benzene and other hydrocarbons, acetylene, pure carbon dioxyde.

Tonnage oxygen plants for the decomposition of air and in particular for the extraction of high purity oxygen and nitrogen in gaseous or liquid states, as single products or with simultaneous production of both gases, for chemical and metallurgical purposes.

GESELLSCHAFT FÜR LINDE'S EISMASCHINEN AKTIENGESELLSCHAFT

ZWEIGNIEDERLASSUNG HÖLLRIEGELSKREUTH · HÖLLRIEGELSKREUTH NEAR MUNICH, WESTERN GERMANY



For gasoline stocks that respond, the economy and simplicity of Tenamene 2 inhibitor sweetening can seldom be equalled by any other treating method

In the presence of caustic and oxygen, Tenamene 2 catalyzes the conversion of mercaptans to disulfides. Being insoluble in caustic, it remains in the gasoline stream to effectively inhibit the formation of gum in the finished gasoline. Thus, it both sweetens and inhibits in essentially one operation.

Tenamene 2 inhibitor sweetening is primarily of interest to processors of catalytically-cracked gasoline. The response of such gasolines to the inhibitor sweetening method can be quickly determined by the following test:

1. Using sour gasoline from the primary caustic scrubber or mercaptan removal unit, put 700 ml. into each of several one-quart bottles.
2. To one group of samples, add Tenamene 2 at a rate of 5 pounds/1,000 bbls. (14.25 mg./liter). To another, add 10 pounds/1,000 bbls. (28.52 mg./liter).
3. Add 10 vol. % of 15° Baumé caustic to each sample.
4. Stopper the bottles, shake thoroughly. Replace stoppers with notched corks and store samples in a dark place at room temperature.
5. Examine at 3-hour intervals and determine the time required for sweetening.

If the results of this test indicate Tenamene 2 inhibitor sweetening to be effective in treating your sour gasoline, we will be glad to aid you in making a detailed study of your sweetening and stabilization requirements. In this study we will help you determine the optimum processing values for your particular operation, including inhibitor concentration, caustic strength and proportion, acid oil content, process temperature and reaction time. For an evaluation sample of Tenamene 2 and more information on the Tenamene 2 inhibitor sweetening method, write or call your Eastman representative, or write to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Basic Procedure for Tenamene 2 Inhibitor Sweetening
(see sketch)

The sour gasoline is washed with 10-15° Baumé caustic. Between 5 and 15 pounds of Tenamene 2 is added per 1000 barrels of hydrocarbon. A small quantity of air is injected into the stream and the gasoline contacted with 20°-30° Baumé caustic. The gasoline is allowed to settle, then pumped to storage. If not already sweet when it goes to storage, the gasoline should sweeten within a few hours after storage.

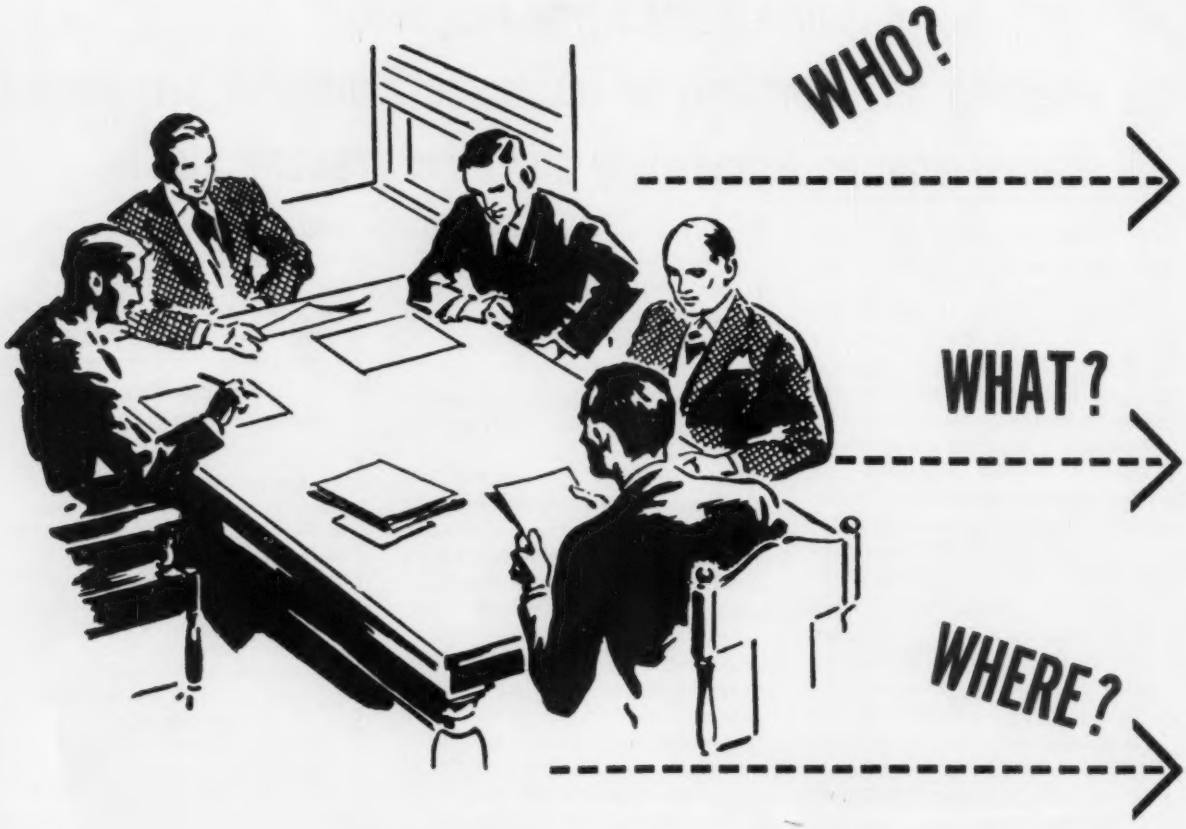
Tenamene 2 inhibitor sweetening is, in almost every instance, more economical than doctor or copper chloride sweetening. Unlike doctor treating, no regeneration step is necessary, and there is no reduction in tetraethyl lead response. Unlike copper chloride treating, Tenamene 2 inhibitor sweetening does not allow the possibility of gum-catalyzing, copper contamination.

Most refineries find that minor modification of existing procedures enables them to adopt this method.

Tenamene 2
an Eastman gasoline additive

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; Atlanta; Boston; Buffalo; Chicago; Cincinnati; Cleveland; Detroit; Greensboro, North Carolina; Houston; Kansas City, Missouri; New York City; Philadelphia; St. Louis.
Western Sales Representatives: Wilson & Geo. Meyer & Company, San Francisco; Denver; Los Angeles; Salt Lake City; Seattle.

With Men

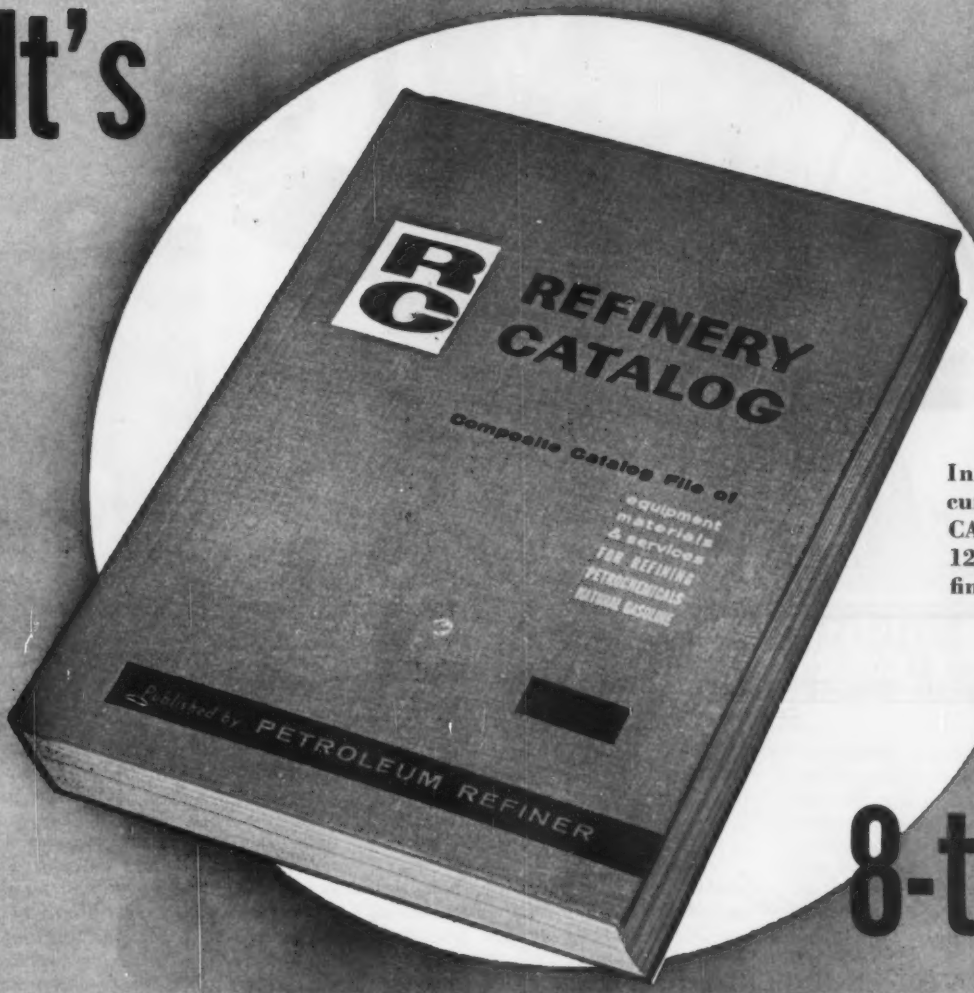


REFINERY CATALOG

Published by Petroleum Refiner

Who Buy And Specify

It's



Included in the current REFINERY CATALOG is the 128-page A·S·A Refinery Piping Code

8-to-1

Look to REFINERY CATALOG for quick answers to your procurement problems in the refining, natural gasoline and petrochemical industry. It's indexed and cross-referenced to save time and eliminate error in planning, buying and specifying for this fast-moving market. That's why buyers and specifiers express a preference of 8-to-1 for REFINERY CATALOG over individual product catalogs.

The next time *you* sit down to figure a job, look *first* in REFINERY CATALOG. You'll find it contributes to greater speed and accuracy.

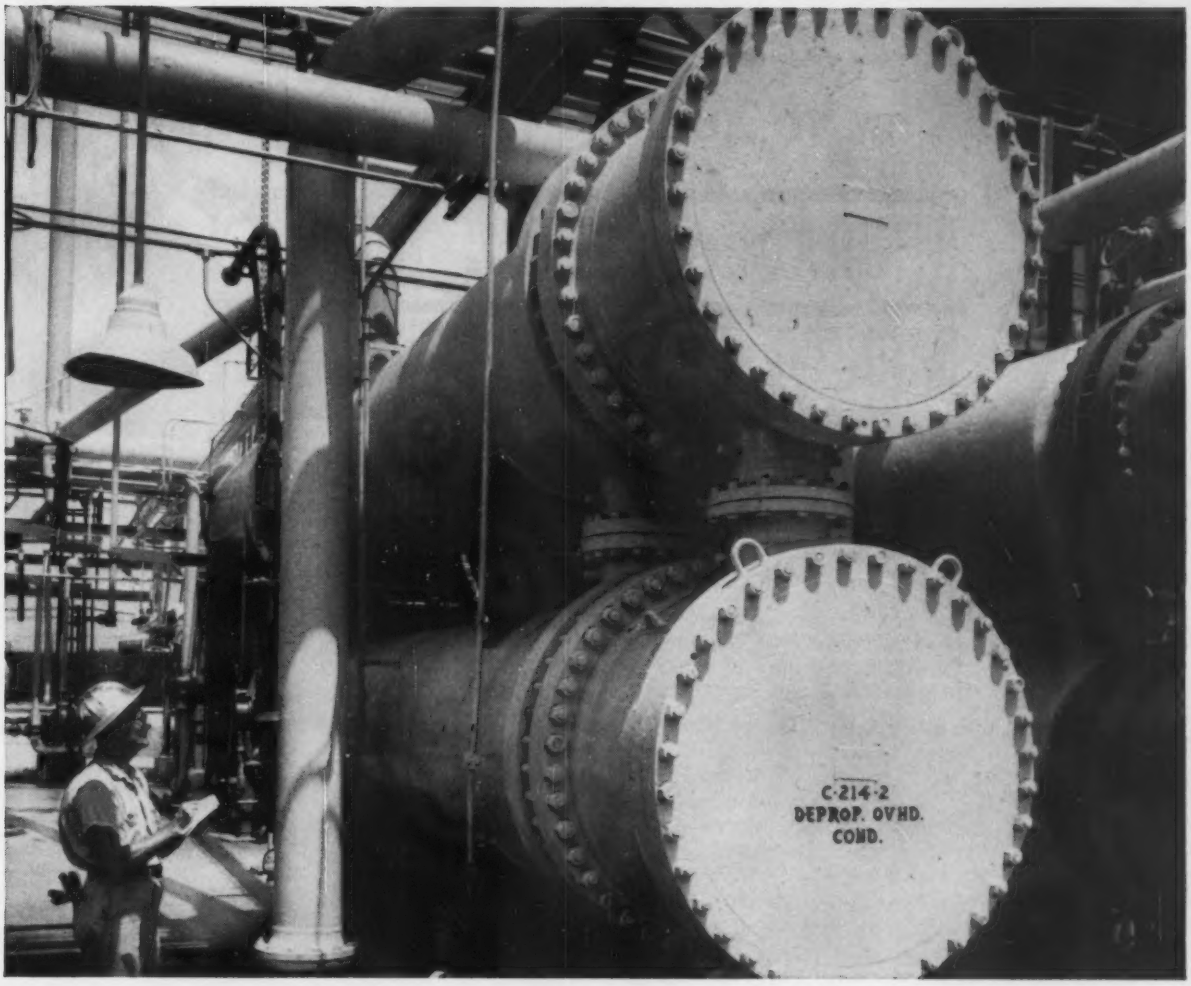
I'll be back Thursday—

CATALYTIC ENGINEERS get out of the office into the field for frequent progress checks on jobs under construction . . . Catalytic engineers advise construction crews and supervisors . . . Catalytic engineers follow through.

This cooperation between home office and project location is another extra that makes it profitable for you to deal with us.

CATALYTIC
CONSTRUCTION COMPANY

PHILADELPHIA 2, PENNSYLVANIA • In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario



How MONEL® Alloy 400 answers major needs in heat exchanger and condenser tubing

At Gulf's Port Arthur, Texas refinery, MONEL* Alloy 400 tubing is still going strong in this condenser after six years. The tubing handles treated cooling tower water at 115-130°F. On the shell side is propane with corrosive H_2S.

Here's how MONEL Alloy 400 (formerly designated MONEL alloy†) answers six important tubing requirements and why it stands up so well in severe refinery service:

1. High strength. This permits use of cost-saving thin walled tubing.

2. Good corrosion resistance. MONEL Alloy 400 withstands attack by chlorides, hydrogen sulfide, caustics, fluorine, hydrogen fluoride, and fresh, salt, or brackish waters.

3. Good heat transfer properties. The thermal conductivity of MONEL Alloy 400 is as follows:

Btu./sq. ft./hr./°F/in.	Cal./sq. cm/sec./°C/cm.
80-212°F . . . 180	27-100°C . . . 0.062
392°F . . . 188	200°C . . . 0.065
752°F . . . 215	400°C . . . 0.074
1112°F . . . 244	600°C . . . 0.084

4. High ductility. MONEL Alloy 400 has good ductility for rolling and bending, permitting unannealed tube ends, as well as tight-rolled joints and hairpin bends.

5. Easy weldability. MONEL Alloy 400 tubes fuse well with steel tube sheets to form a strong, sound weld and the coefficient of expansion is close to that of the steel tube sheets.

6. Long-length tubing available. Some sizes of MONEL Alloy 400 tubes are available in lengths up to 85 feet. Thus, designers can effect economies by specifying a longer heater of smaller diameter. Tubing is available in ½ to 5-inch diameters and in wall thicknesses from 0.025 to 0.300 inch.

Write for the helpful booklet "How Huntington Alloys Help to Raise Refinery Output and Lower Maintenance Costs."

*Registered trademark of The International Nickel Company, Inc.

†A new folder available on request, lists all of the alloys available from the Huntington Division and gives data on the chemical composition of these alloys.

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17 West Virginia

INCO TRADE MARK

MONEL® NICKEL-COPPER ALLOYS

For more data on advertised products, use cards, last page.

THREE MAIN OBJECTIVES COMMON TO ALL PLANT OPERATIONS...

UPGRADE PRODUCT QUALITY

IMPROVE OPERATING EFFICIENCY

REDUCE MAINTENANCE COSTS

. . . all important goals and a vital part of any plant operating program.

We at Warner Lewis Company believe that our products can contribute substantially to the achievement of these goals in your plant. With the experience and knowledge gained by countless in-plant applications of our water separator/filters we welcome the opportunity to discuss the installation and operation of our equipment with you.

Check this list for just a few of the many applications now serving the industry which might be of help to you:

UPGRADE PRODUCT QUALITY

_____1. Products to storage: Warner Lewis separator/filters remove essentially all solids and 100% of free or entrained water, even from product treated with corrosion inhibitors forming tight emulsions.

_____2. Caustic treating: Special Warner Lewis coalescing media remove traces of entrained caustic water from treating and washing operations.

_____3. Loading Rack: Warner Lewis separator/filters de-haze finished products, removing water cloud and solids such as catalyst fines. Insurance against costly customer complaint.

IMPROVE OPERATING EFFICIENCY

_____1. Warner Lewis separator/filters remove all free water and solids from process feed stocks, eliminate catalyst dilution.

_____2. Elimination of free water in process streams checks corrosion, cuts costly maintenance in heat exchangers and other process equipment, reduces inhibitor costs.

_____3. Where complete dehydration is used, Warner Lewis separator/filters ahead of desiccant beds, remove all free water and provide longer desiccant life.

REDUCE MAINTENANCE COSTS

_____1. 100% free water removal checks interior corrosion in lines, vessels and storage tanks, eliminates costly repairs or replacement.

_____2. Efficient filtration eliminates solids build-up in lines, vessels and storage tanks, eliminates costly cleaning operations.

_____3. Warner Lewis separator/filters prevent dilution or fouling of catalyst with water and solids.

FREE INFORMATION — Let us show you the economy of installing and operating Warner Lewis separator/filters in your plant. Mail this check list today to:

WARNER LEWIS COMPANY

DIVISION OF FRAM CORPORATION

PROCESS DEPT. • P. O. BOX 3096 • TULSA, OKLAHOMA

IN CANADA: FRAM CANADA LTD. STRATFORD, ONTARIO

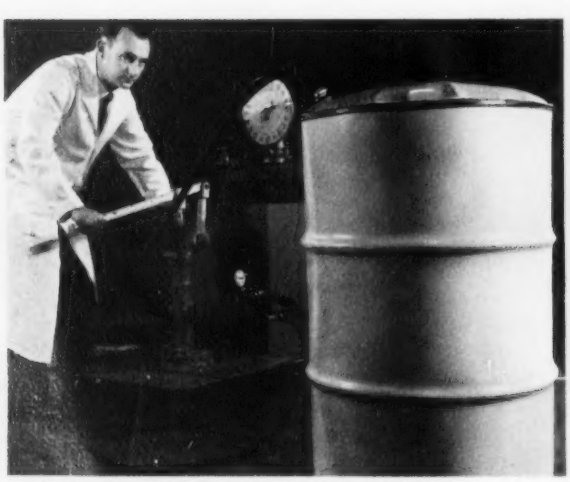
This drum is doomed!

How we beat our drums to make them better

This is one of several drums we yank from our production line periodically. These chosen few won't ever be shipped because they'll be beaten, bent, crushed, expanded, collapsed. The reason: We want to make sure that U.S. Steel drums can *really* take it—and meet the most rigid specifications.

To test the drums, our inspectors will fill one with water, close it, hoist it above solid concrete, then drop it at least four feet onto its top edge. On another test, we force water into a drum until it fails under pressure. The vacuum test sucks the atmosphere out of a drum until it collapses. Another grueling drum test is the shake table which simulates the rocking, galloping motion of roughest shipping conditions. (Every U.S. Steel drum is air-tested during production for tightness). These tests punish drums far beyond normal requirements. But they're an excellent way to check welds, seams —and to prove the extra bit of toughness and quality that goes into every U.S. Steel drum.

When you want quality for your products, order the best steel drums made. Order your drums from U.S. Steel Products. Complete specifications and plant locations are available on the last page.



Hydrostatic Test: It takes a lot of water pressure to make a steel drum leak—notice how the top bulges, but no sign of leaks.

Vacuum Test: The sides of this steel drum finally cave in as the last bit of air is removed by the vacuum machine.

Left: *Drop Test:* This filled steel drum is about to be dropped to the floor, testing the double seam chime.

Below: *Air Test:* Completed drums are tested automatically on this production line for air tightness.

Exposure Test: This graveyard is the end of the line for these drums—they'll sit here for years braving the elements as a durability test.

—	57	18	18	22½	34 11/32	35 15/16	23 7/16	49.7	11/0	300	370
17C	55	16	16	22½	33 5/32	34¾	23 7/16	60.6	10/9	300	370
17E	55	18	18	22½	33 5/32	34¾	23 7/16	48.6	10/9	300	370
17E	55	20	18	22½	33 5/32	34¾	23 7/16	40.1	10/9	300	370
—	33	19	19	18¼	30 1/32	31⅝	19 9/16	31.2	6/8	430	540
—	33	18	18	18¼	30 1/32	31⅝	19 9/16	35.6	6/8	430	540
17E	30	20	20	18¼	27 9/32	28⅜	19 9/16	25.3	6/1	570	670
17E	30	19	19	18¼	27 9/32	28⅜	19 9/16	29.3	6/1	570	670
17C	30	18	18	18¼	27 9/32	28⅜	19 9/16	33.5	6/1	570	670
—	30	16	16	18¼	27 9/32	28⅜	19 9/16	41.7	6/1	570	670
—	16	22	22	13 15/16	25 27/64	26⅛	14⅞	14.3	3/6	1040	1250
—	16	20	20	13 15/16	25 27/64	26⅛	14⅞	17.0	3/6	1040	1250

STANDARD SHIPPING CONTAINERS TIGHT HEAD DRUMS

ICC Spec.	Capacity Gallons	Gauge Body	Gauge Head and Bottom	Inside Diameter	Inside Height	Overall Height	Diameter Over Rolling Hoops	Approx. Tare Weight	Ocean Cube	Approx. No. Per Carload	
										40′	50′

Note: All the drums listed, as well as our complete line of pails, are available painted (black or other standard colors), decorated, lined, galvanized (hot-dip), tinned (hot-dip), stainless, and embossed (names, number, symbols, trademarks as requested). **Plant Locations:** Alameda, California, 1849 Oak Street, Phone: Lakehurst 2-5511 • Camden 1, New Jersey, P. O. Box 530, Phone: Normandy 3-8000 • Chicago 27, Illinois, 14700 Harvard Avenue, Phone: Interocean 8-9610 • Los Angeles 58, California, 5100 Santa Fe Avenue, Phone: Ludlow 7-2121 • New Orleans 23, Louisiana, P. O. Box 23152, Phone: Vernon 3-2851 • Port Arthur, Texas, P. O. Box 1440, Phone: Yukon 2-9455 • Sharon, Pennsylvania, P. O. Box 251, Phone: Gibson 8-6841

STANDARD SHIPPING CONTAINERS FULL REMOVABLE HEAD DRUMS

ICC Spec.	Capacity Gallons	Gauge Body	Gauge Cover	Gauge Bottom	Gauge Ring	Inside Height	Overall Height	Inside Diameter	Outside Diameter	Approx. Tare Weight	Ocean Cube	Approx. No. Per Carload	
												40′	50′
—	57	18	18	18	16	34 15/32	36 5/16	22½	23 27/32	52.4	12/0	300	375
—	55	18	18	18	16	33 7/32	35 1/16	22½	23 27/32	51.2	11/8	300	375
17H	55	18	18	16	12	32 27/32	34 13/16	22½	23 27/32	55.6	11/8	300	375
—	55	16	16	16	12	32 27/32	34 13/16	22½	23 27/32	66.2	11/8	300	375
—	33	19	19	19	16	30 5/32	31 13/16	18¼	19 19/32	33.3	7/5	432	540
—	33	18	18	18	16	30 5/32	31 13/16	18¼	19 19/32	37.8	7/5	432	540
—	33	16	16	16	12	30 5/32	31 13/16	18¼	19 19/32	49.3	7/5	432	540
—	30	20	20	20	16	27 11/32	29	18¼	19 19/32	27.2	6/9	576	670
—	30	19	19	19	16	27 11/32	29	18¼	19 19/32	31.4	6/9	576	670
—	30	18	18	18	16	27 11/32	29	18¼	19 19/32	35.6	6/9	576	670
17H	30	18	18	18	12	27 11/32	29⅛	18¼	19 19/32	38.1	6/9	576	670
—	30	16	16	16	12	27 11/32	29⅛	18¼	19 19/32	46.6	6/9	576	670
—	16	22	22	22	16	25⅜	26⅜	13 15/16	14⅞	15.3	3/6	1040	1250
—	16	20	20	20	16	25⅜	26⅜	13 15/16	14⅞	18.0	3/6	1040	1250

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For more data on advertised products, use cards, last page.

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the Walworth companies: Alloy Steel Products Co. • Conoflow Corp. • Grove Valve & Regulator Co. • M&H Valve and Fittings Co.

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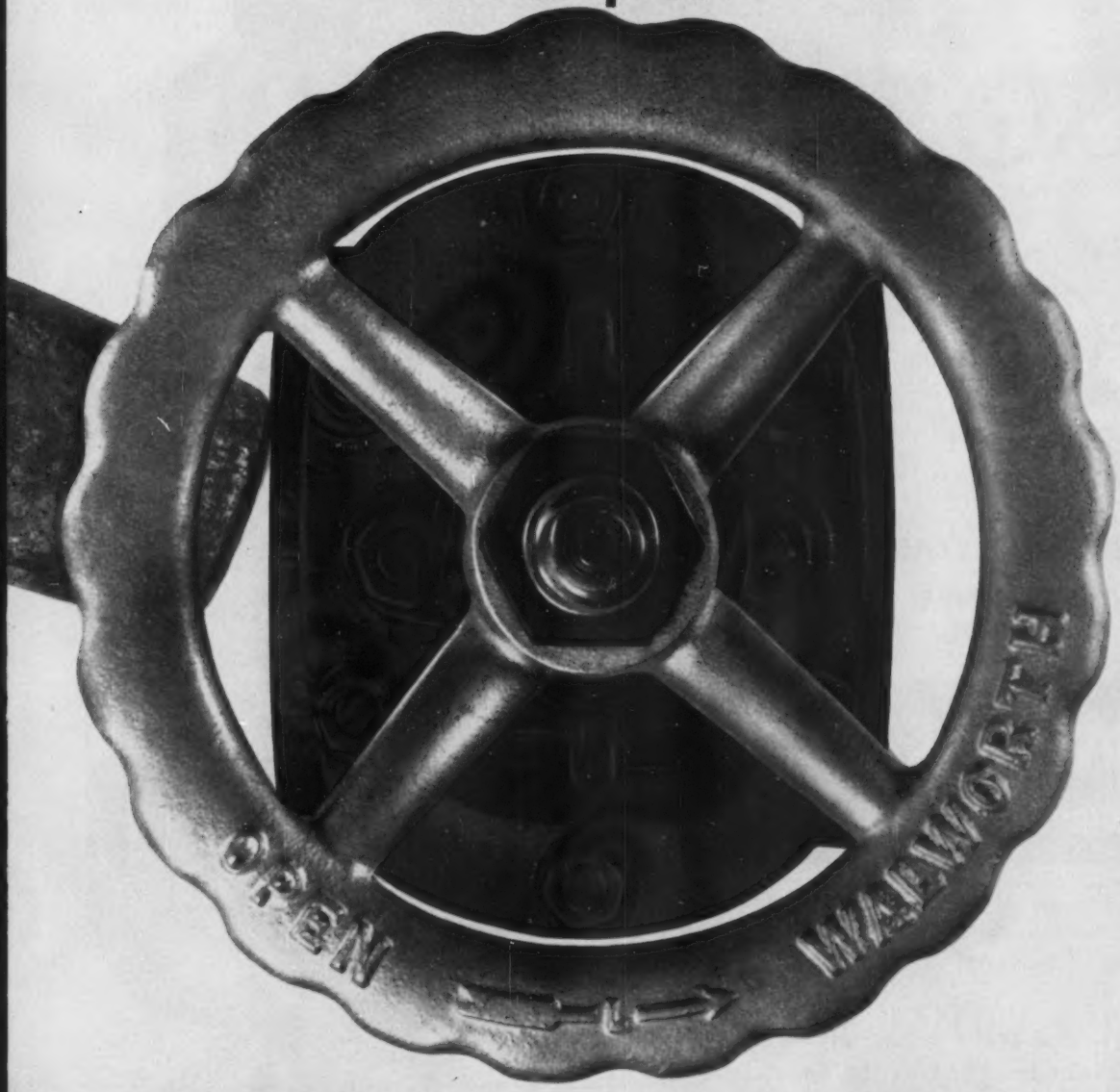

*Walworth specifies minimum elongation of 18%

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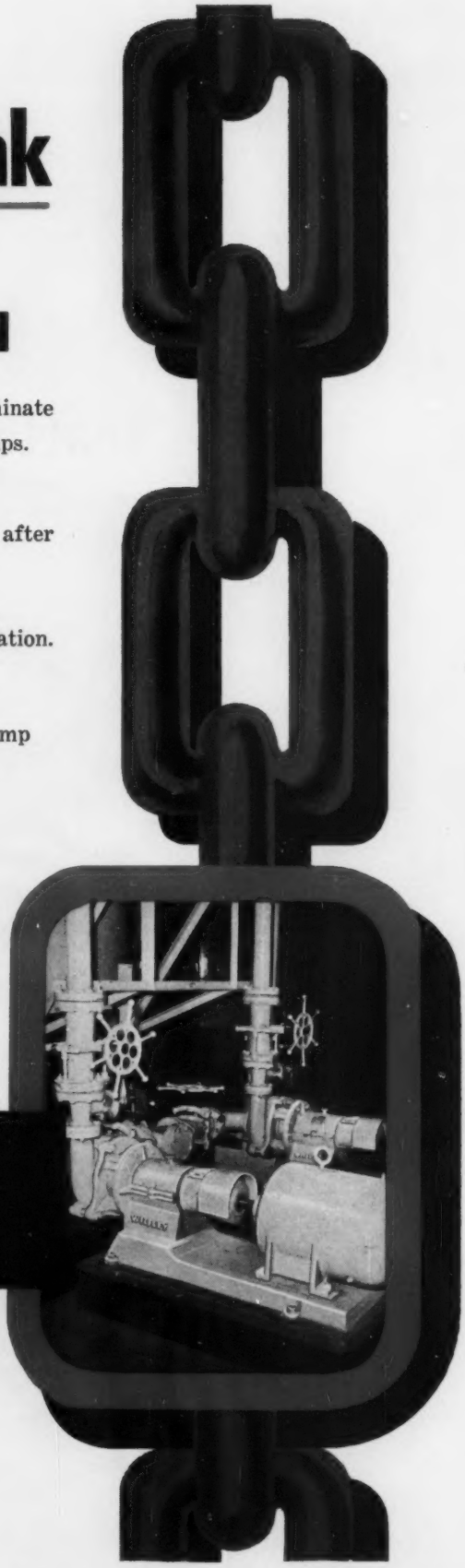

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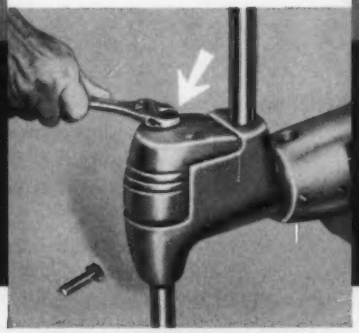
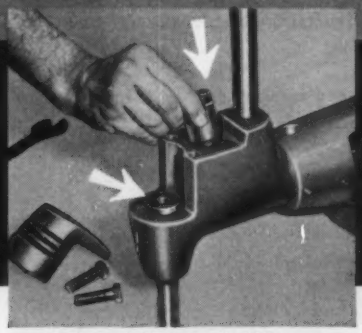
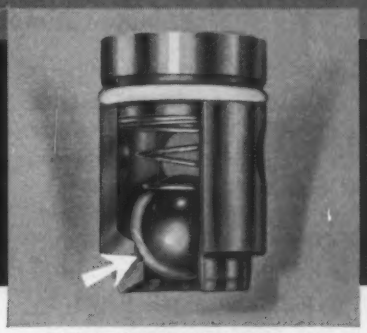


Quick, Easy Accessibility by simply unscrewing two screws, removing cover. Screws are not exposed to process fluids, in no way disturb piping.



Suction and Discharge Cartridges, not threaded or pressed, lift out. Thread galling is impossible. Use valve cover screw as a tool to lift out cartridge.



Triple Seat Design literally improves valve efficiency with wear. Top seat guides ball, virtually eliminating wear on second and third seats.

E-Z CLEAN Valves mean maximum convenience for inspection, cleaning or replacement, actually can be changed in minutes. Valves are available in a variety of corrosion-resistant materials for a wide range of operations. Exclusive American design enables valves to be changed readily without disconnecting piping.

SPRING LOADED design increases volumetric efficiency, reduces back-flow and destructive shock-forces due to inertia. Spring reduces time required for complete valve closing, minimizing back-flow and improving accuracy. Spring-loaded valves are particularly effective with slurries and high viscosity liquids.

TRIPLE INTEGRAL SEATS actually increase valve life *three times.* The first seat alone would normally provide the service life of a conventional single-seat check valve. Even after wear occurs on the first seat, it continues to act as a guide and virtually eliminates wear on second and third seats.

Series 300

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American Controlled Capacity Pumps are available in three Series illustrated at left—electric and air-operated, wide pressure and capacity ranges. Series 300 Pumps are externally adjustable *while in operation* by a stationary hand-wheel. Internal adjusting mechanism is immersed in oil. Available for automatic adjustment or pneumatic and electric control. Designed and manufactured with American's unmatched skill and experience, these pumps perform with maximum precision, less downtime, lowest possible maintenance and low parts inventory. Write for complete information.

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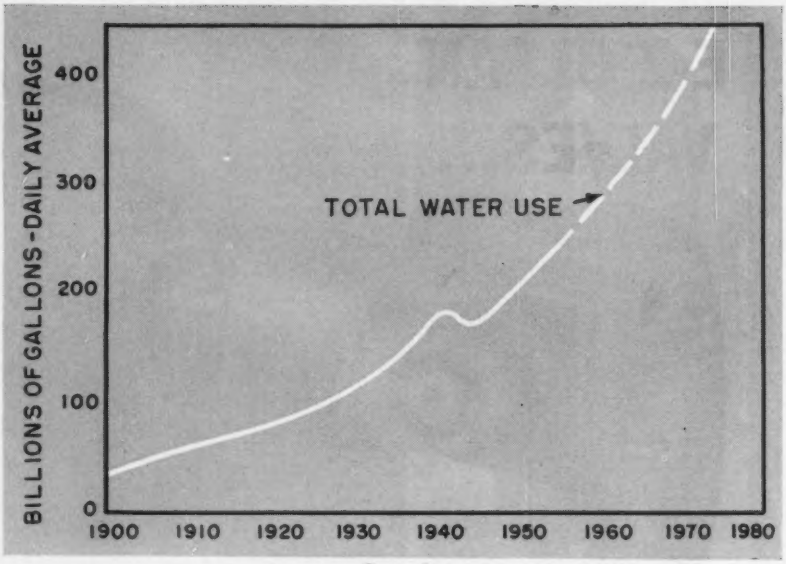

Figure 1

WASTING WATER IN YOUR

■ There are ample opportunities for the conservation of water in most industrial plants

WATER IS ONE of our most vital resources. Considerable concern has been expressed from time to time over the adequacy of our water resources. This concern is justified because of the enormous current water usage and the rate of increased usage predicted for the future as shown by Figure 1. The current water usage by industry alone is estimated as 70 billion gallons per day. It is anticipated that daily usage will soar to 115 billion gallons by 1975. Water requirements for various industries are typified by the data presented in Figure 2. With an expanding population and industrial growth it is important that serious attention by industry be given to the conservation and reuse of our water resources.

Industrial plants that are located in drought areas have been forced to cope with a water shortage problem much sooner than anticipated. In some of these cases, sewage plant effluent has been used for makeup to boilers and recirculating cooling water systems. The problems encountered in the treatment of sewage plant effluent to make it suitable for these purposes is thoroughly covered by Betz Technical Paper No. 138, a copy of which is available on request.

Many industrial plants located in other areas where water supplies have been considered adequate and inexhaustible, have found it profitable to conduct surveys of their water usages. Often, surveys of this type uncover unnecessary water losses, inefficient operations and equipment obsolescences. The correction of these conditions has led to a saving not only in water, but of dollars as well. A recent survey conducted at a chemical processing plant dramatically illustrates what can be done.

TYPICAL WATER REQUIREMENTS

Industry	Gallons per Tons
PETROLEUM	35,000
STEEL	65,000
PAPER	70,000
RUBBER	30,000

Figure 2

Case History

A chemical processing plant, considering an expansion program, found that the water supplies might not prove adequate for the anticipated operating conditions. The normal source of well water was already being supplemented by the use of city water which was already in short supply. One of the three wells normally used had been abandoned because of evidence of salt water intrusion. A simplified flow sheet of water usage for the plant is illustrated by Figure 3.

The survey revealed that a large quantity of hot condensate was being dumped to waste because of frequent contamination from process evaporators which introduced foam producing materials into the condensate. When this condensate returned to the boilers, severe boiler water carryover occurred.

Trouble also occurred with the lime-soda softener. The supplemental use of city water along with the normal well water created such a wide variation in makeup water characteristics that it was impossible to maintain proper balances. These poor balances resulted in the need for frequent backwashing of the filters and the maintenance of an abnormally high blowdown rate on the boilers.

The recirculating cooling water system contained numerous bleed-off points for miscellaneous water usages which made it uneconomical

to treat the system for prevention of corrosion. The corrosion products that accumulated were interfering with heat transfer, requiring added water flow to maintain process temperatures.

Briefly, the corrective measures applied involved the application of an *antifoam to the process evaporators* which eliminated contamination of the condensate. As a safety measure, however, an alarm system was installed which also operates a valve to divert the condensate, if and when contamination occurs. The return of the hot condensate materially reduced makeup requirements to the boiler so that the available city water proved more than adequate to handle boiler makeup requirements for the proposed operating conditions. With the use of city water alone for makeup to the boilers, uniform softener balances have been maintained and the filter backwash and boiler blowdown have been reduced to normal requirements.

Savings in heat, water treatment and water requirements far exceed the cost of the process antifoam and the cost of the alarm system used to correct the problem.

In addition, a check of the numerous draw-off points from the cooling system revealed unnecessary waste of water through open-ended hoses used periodically for washing equipment and left running. Cooling water for bearings and compressors was not returned to the main cooling water system. Elimination of these water losses permitted the cooling system to cycle and decreased makeup requirements to the point where the two existing wells could satisfy the water demands. These savings in water, in turn permitted corrosion control treatment to be justified economically. A check of the third well which had been abandoned for evidence of salt water intrusion indicated that the salt content was within a range to permit its use in the cooling system if necessary. This well was connected for emergency use to the cooling system. The effectiveness of the cooling water corrosion control treatment has limited corrosion of the steel parts in the system to less than one mil per year. Design temperatures and normal pressure drops through the heat exchangers are now maintained.

PLANT ?

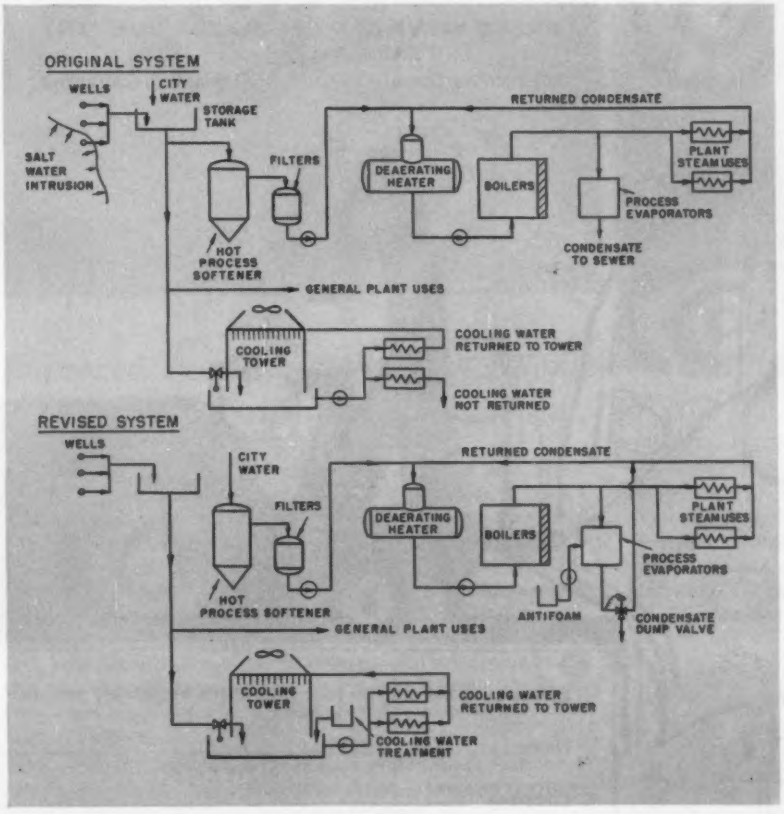

Figure 3

This survey and numerous others conducted by the Betz Consulting Division has revealed that there exist ample opportunities in many plants to bring about water conservation and oftentimes water re-use.

A survey of your plant water usages, treatment methods and water wastes may produce benefits both in water savings and dollar savings. Perhaps a process antifoam may be the answer. Talk it over with the Betz Engineer next time he visits your plant.

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■ CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

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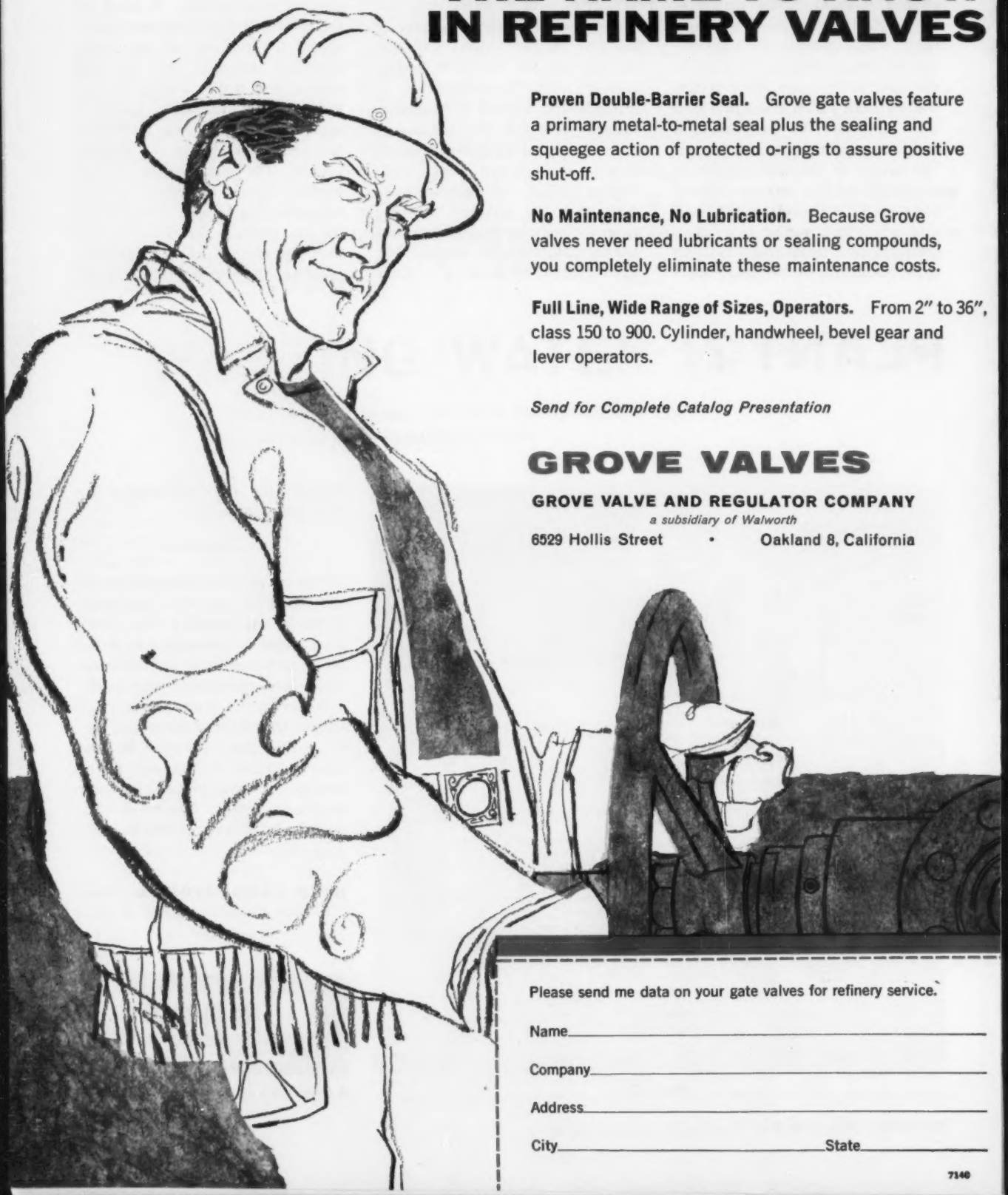

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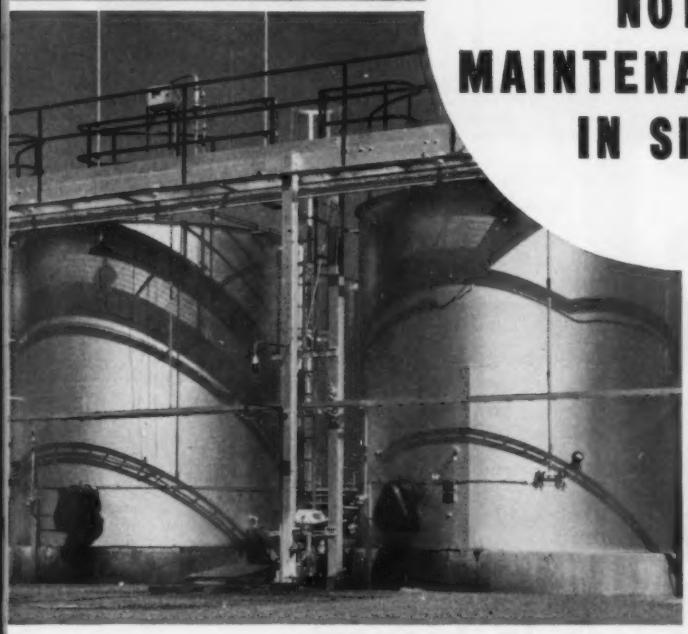

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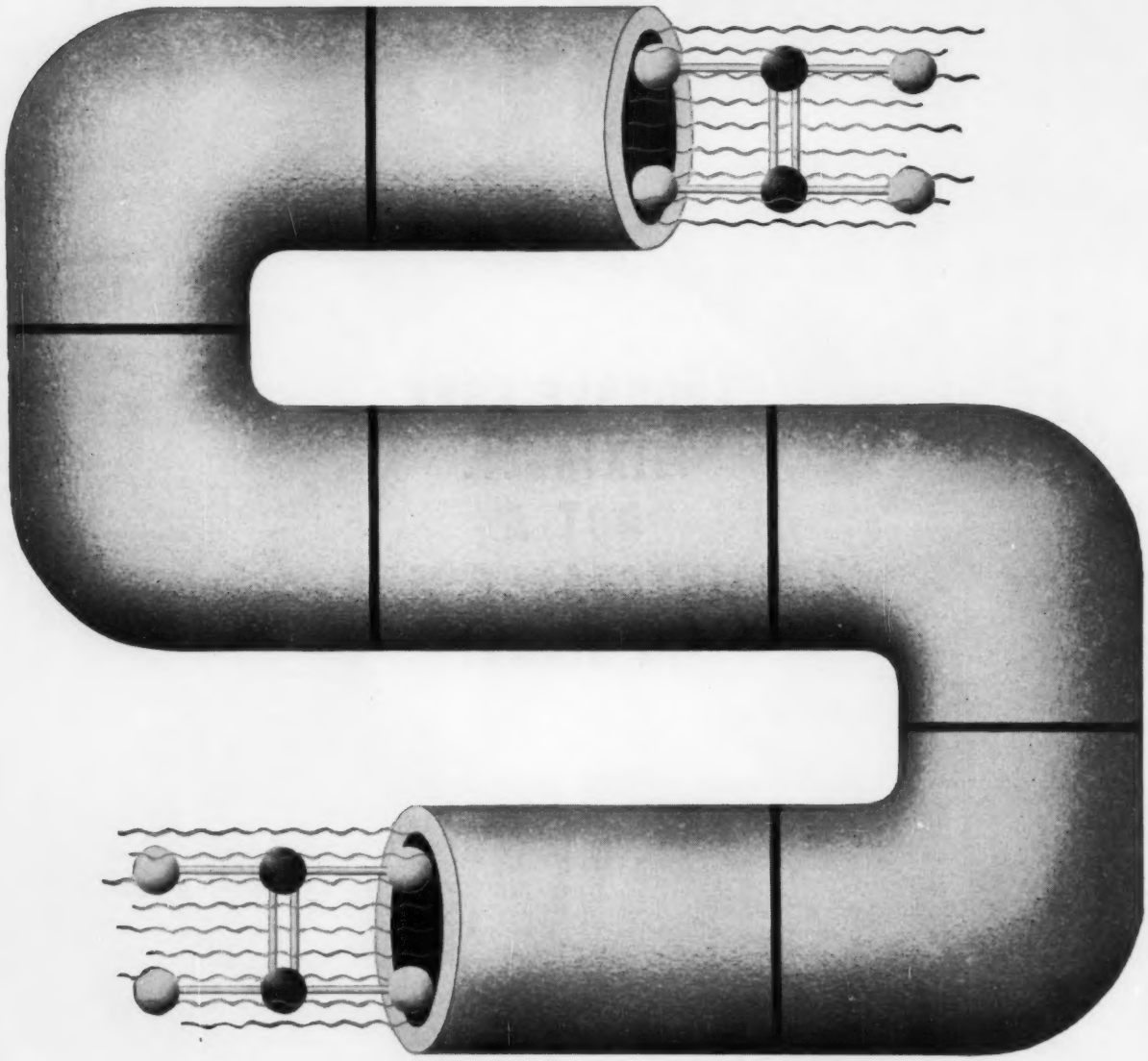

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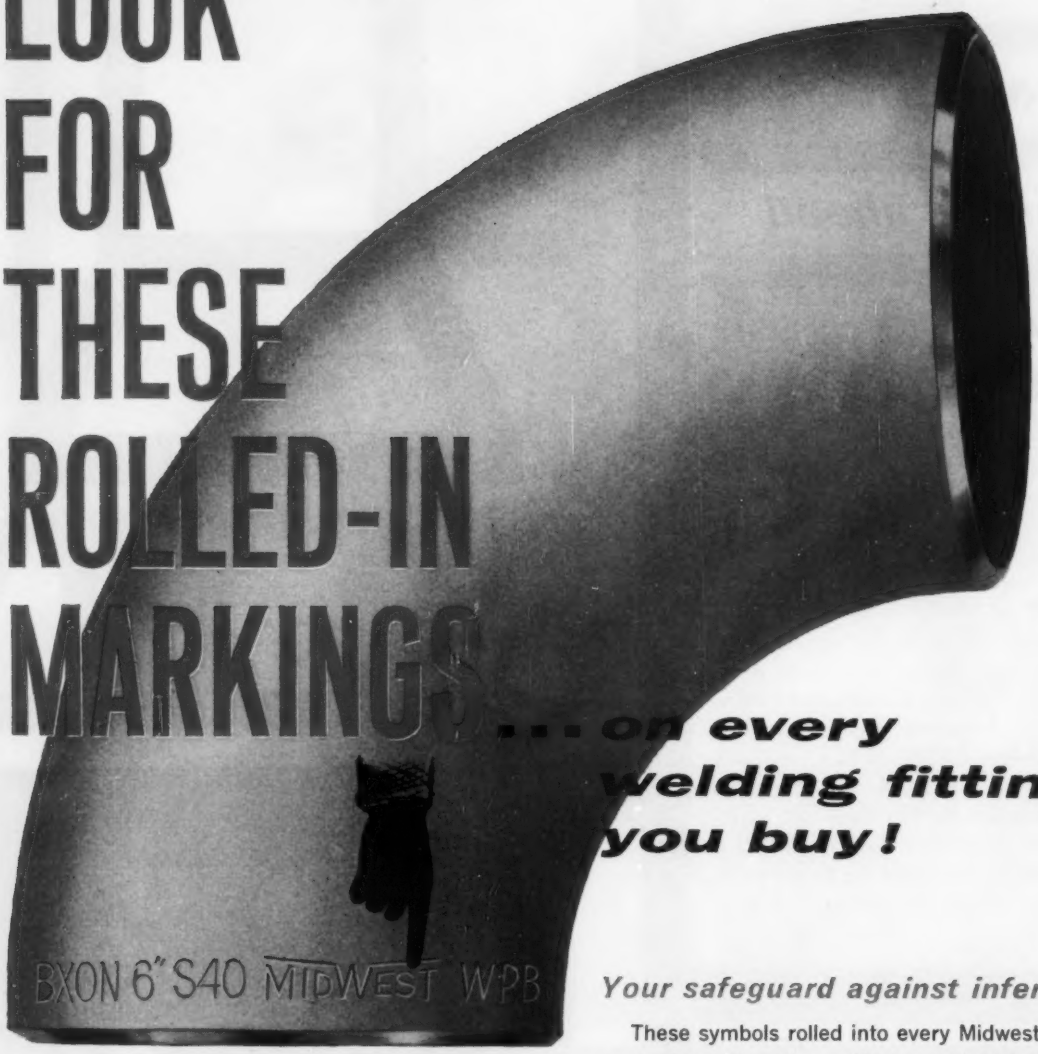

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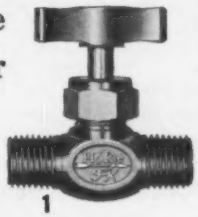

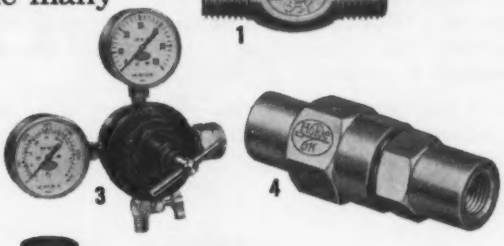

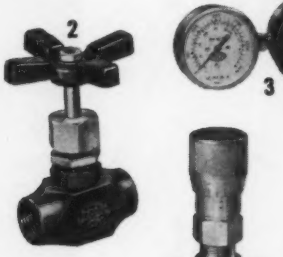

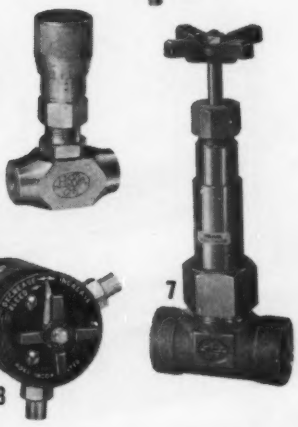

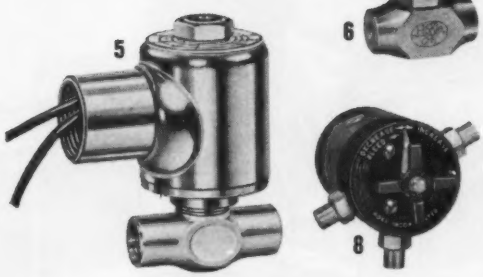

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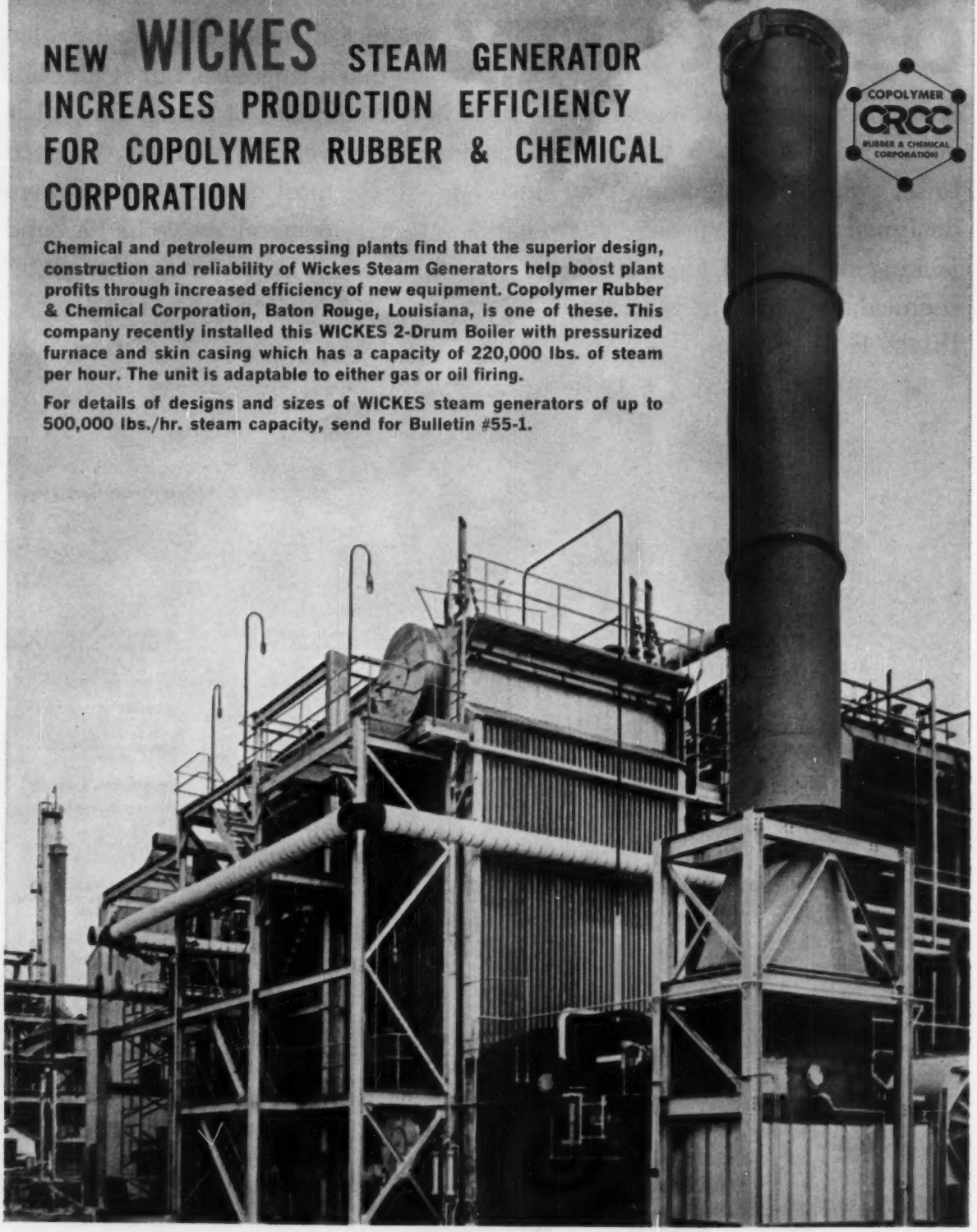
For more data on advertised products, use cards, last page.

NEW WICKES STEAM GENERATOR INCREASES PRODUCTION EFFICIENCY FOR COPOLYMER RUBBER & CHEMICAL CORPORATION

Chemical and petroleum processing plants find that the superior design, construction and reliability of Wickes Steam Generators help boost plant profits through increased efficiency of new equipment. Copolymer Rubber & Chemical Corporation, Baton Rouge, Louisiana, is one of these. This company recently installed this WICKES 2-Drum Boiler with pressurized furnace and skin casing which has a capacity of 220,000 lbs. of steam per hour. The unit is adaptable to either gas or oil firing.

For details of designs and sizes of WICKES steam generators of up to 500,000 lbs./hr. steam capacity, send for Bulletin #55-1.

COPOLYMER CRCC RUBBER & CHEMICAL CORPORATION



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Division of The Wickes Corporation

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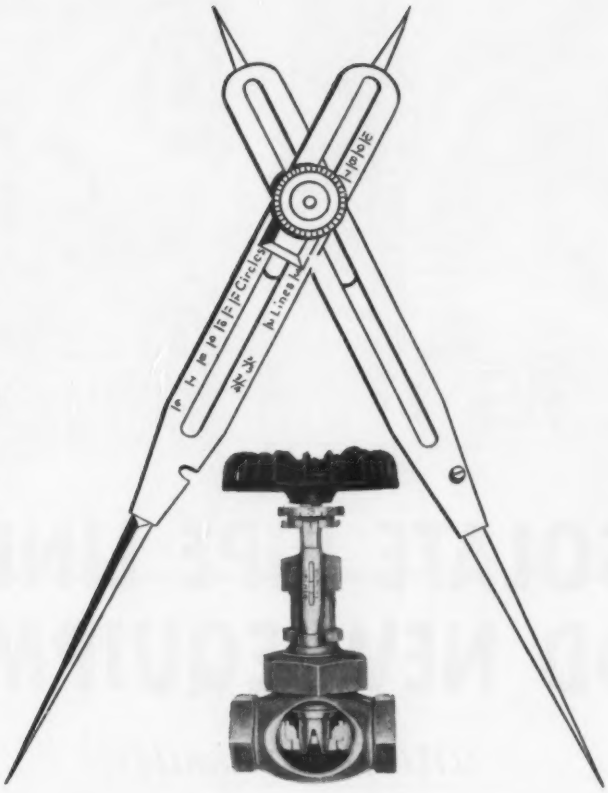
176



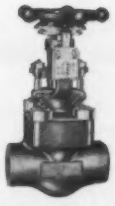
PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required—flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.



Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

MAXWELL MM& MANNING & MOORE INC. TRADE MARK

HANCOCK "FLOCONTROL" VALVES

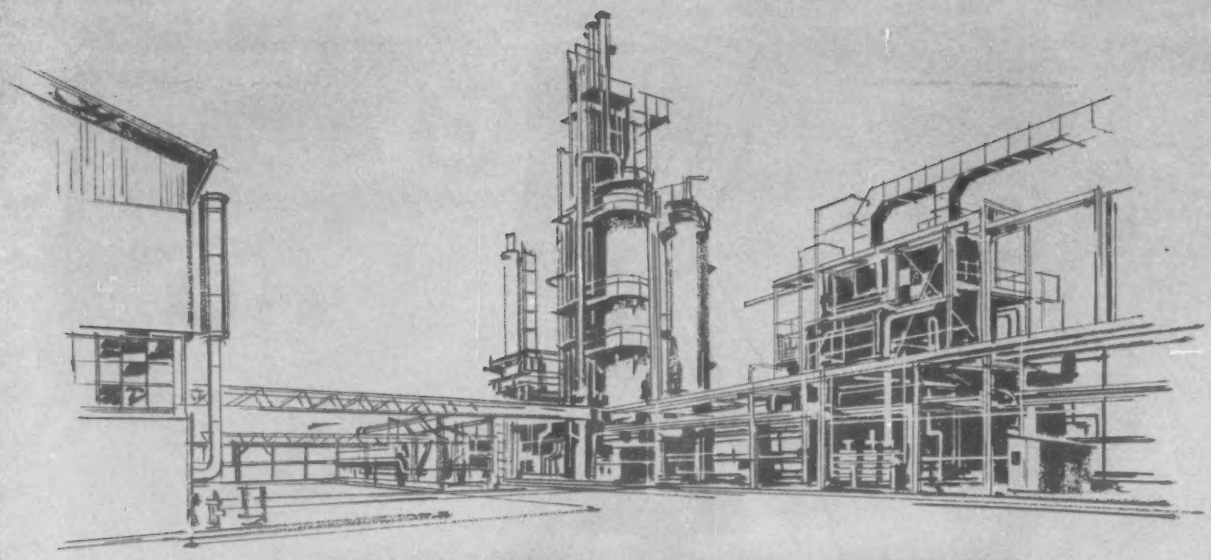
A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division • Watertown, Massachusetts

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

For more data on advertised products, use cards, last page.



ISOLATE PIPE LINES ...ADD NEW EQUIPMENT

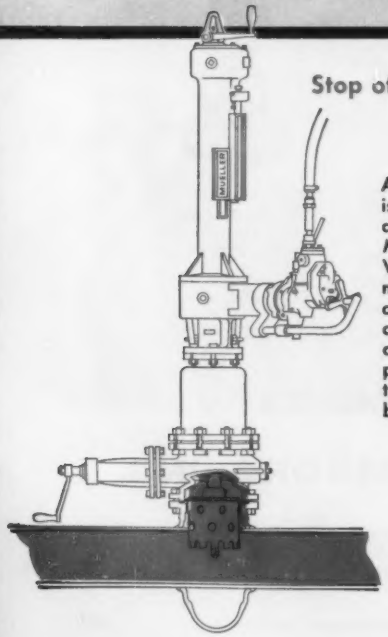
under pressure!

You can make repairs... isolate lines that need replacing... tie-in new piping... install new equipment—without interrupting flow or loss of production. There is no blowing of gas or fluids as you make permanent connections under full pressure and in complete safety.

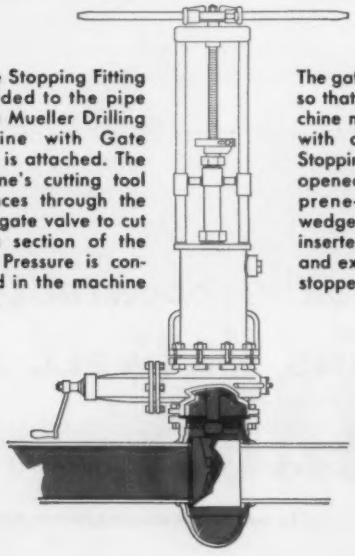
Mueller® No-Blo® methods and products enable you to work on piping systems whenever needed. A complete line of Mueller fittings, valves and equipment provides an answer to most every problem of working on lines under pressure.

Basic steps of Mueller No-Blo Methods are shown briefly in these illustrations...

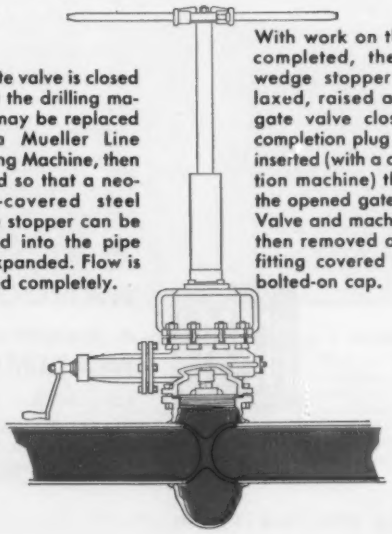
Stop off high pressure lines where no control valves exist—



A Line Stopping Fitting is welded to the pipe and a Mueller Drilling Machine with Gate Valve is attached. The machine's cutting tool advances through the open gate valve to cut out a section of the pipe. Pressure is contained in the machine body.



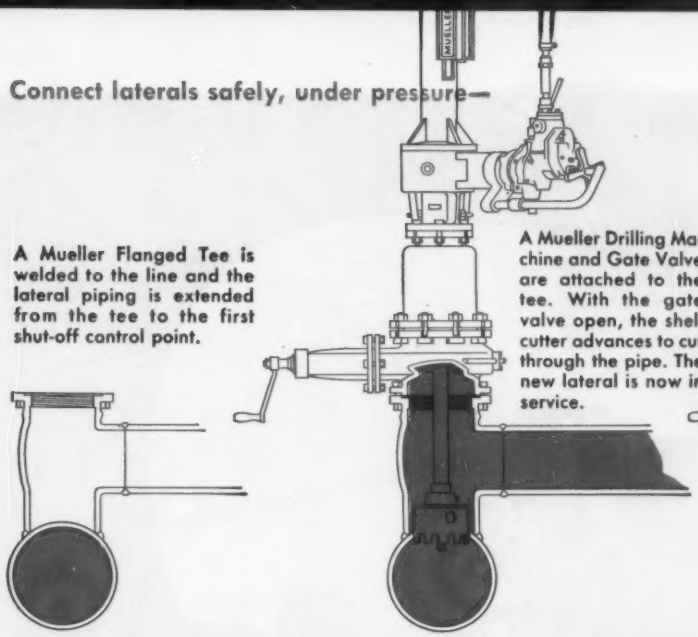
The gate valve is closed so that the drilling machine may be replaced with a Mueller Line Stopping Machine, then opened so that a neoprene-covered steel wedge stopper can be inserted into the pipe and expanded. Flow is stopped completely.



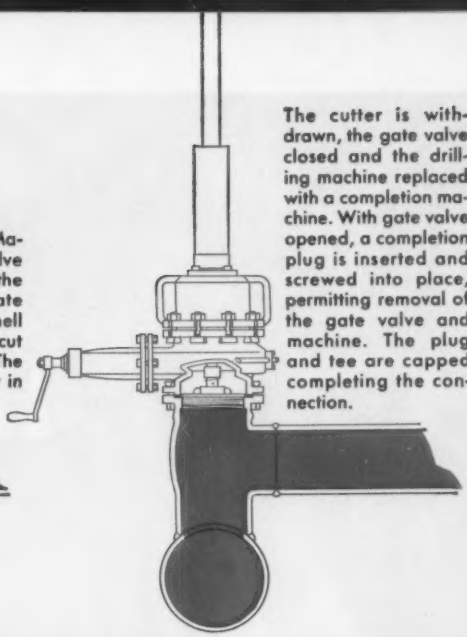
With work on the line completed, the steel wedge stopper is relaxed, raised and the gate valve closed. A completion plug is then inserted (with a completion machine) through the opened gate valve. Valve and machine are then removed and the fitting covered with a bolted-on cap.

Connect laterals safely, under pressure—

A Mueller Flanged Tee is welded to the line and the lateral piping is extended from the tee to the first shut-off control point.

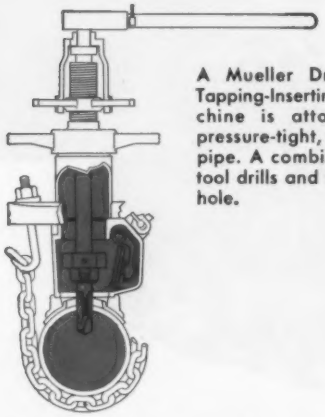


A Mueller Drilling Machine and Gate Valve are attached to the tee. With the gate valve open, the shell cutter advances to cut through the pipe. The new lateral is now in service.



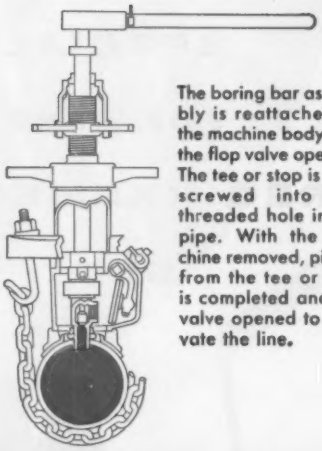
The cutter is withdrawn, the gate valve closed and the drilling machine replaced with a completion machine. With gate valve opened, a completion plug is inserted and screwed into place, permitting removal of the gate valve and machine. The plug and tee are capped completing the connection.

Tap a hot line without welding—



A Mueller Drilling-Tapping-Inserting Machine is attached, pressure-tight, to the pipe. A combination tool drills and taps a hole.

The tool is retracted and a flop valve in the body is closed to contain the pressure. The tool can then be removed and a valve tee or stop in closed position is attached to the boring bar.

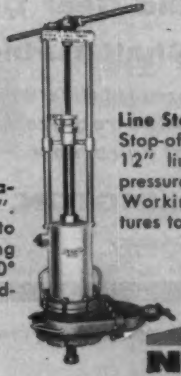


The boring bar assembly is reattached to the machine body and the flop valve opened. The tee or stop is then screwed into the threaded hole in the pipe. With the machine removed, piping from the tee or stop is completed and the valve opened to activate the line.

Mueller No-Blo products to save time and money:

Large Drilling Machines—Cuts to 12". Working pressure to 500 p.s.i. Working temperatures to 500° F. Power or hand-operated.

Completion Machines — For fittings through 12". Working pressures to 500 p.s.i. Working temperatures to 250° F.

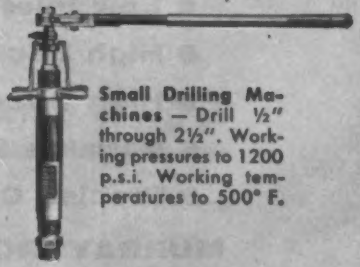


Line Stopper Units—Stop-off ¾" through 12" lines. Working pressures to 500 p.s.i. Working temperatures to 250° F.

Flanged Tees—Sizes from 3" through 8". Pressure ratings to 1200 p.s.i. Temperature ratings to 500° F.

Line Stopper Fittings — Sizes from ¾" through 12". Welding or mechanical joints. For steel, thin-wall steel or cast-iron pipe. Pressure ratings to 1200 p.s.i.

Valve Tees — Sizes through 2". Welding or threaded inlet and/or outlet. Pressure ratings to 1200 p.s.i. (Machine inserted Valve Tee — 250 p.s.i.)



Small Drilling Machines — Drill ½" through 2½". Working pressures to 1200 p.s.i. Working temperatures to 500° F.

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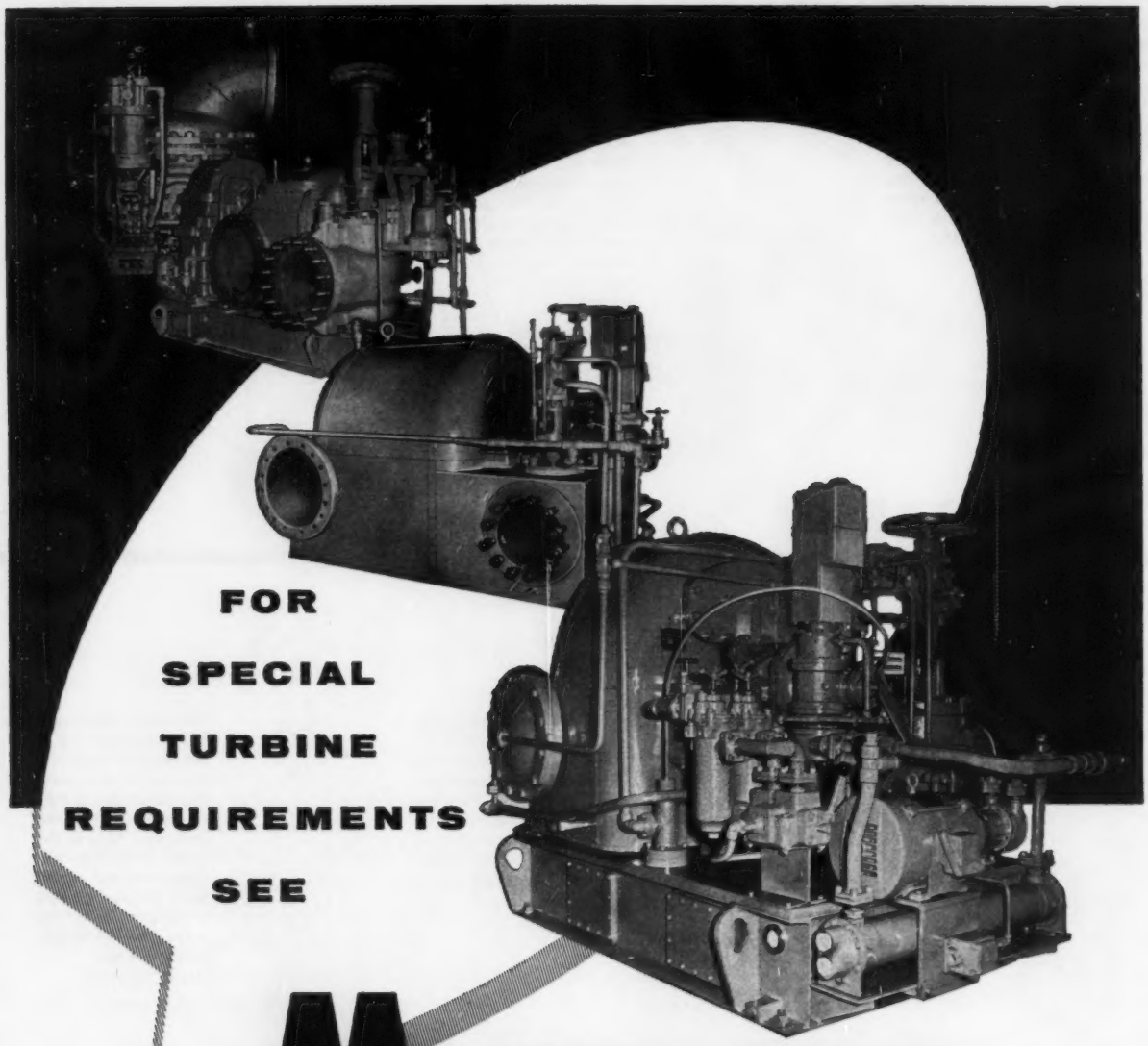

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Murray TURBINES

- Low Inlet Pressures
- High Back Pressures
- High Speeds
- Variable Speed Ranges
- Precise Control
- Multi-Valve Designs
- Double End Gear Drives
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Our nearest representative will help you solve your turbine requirements. His name gladly sent on request.

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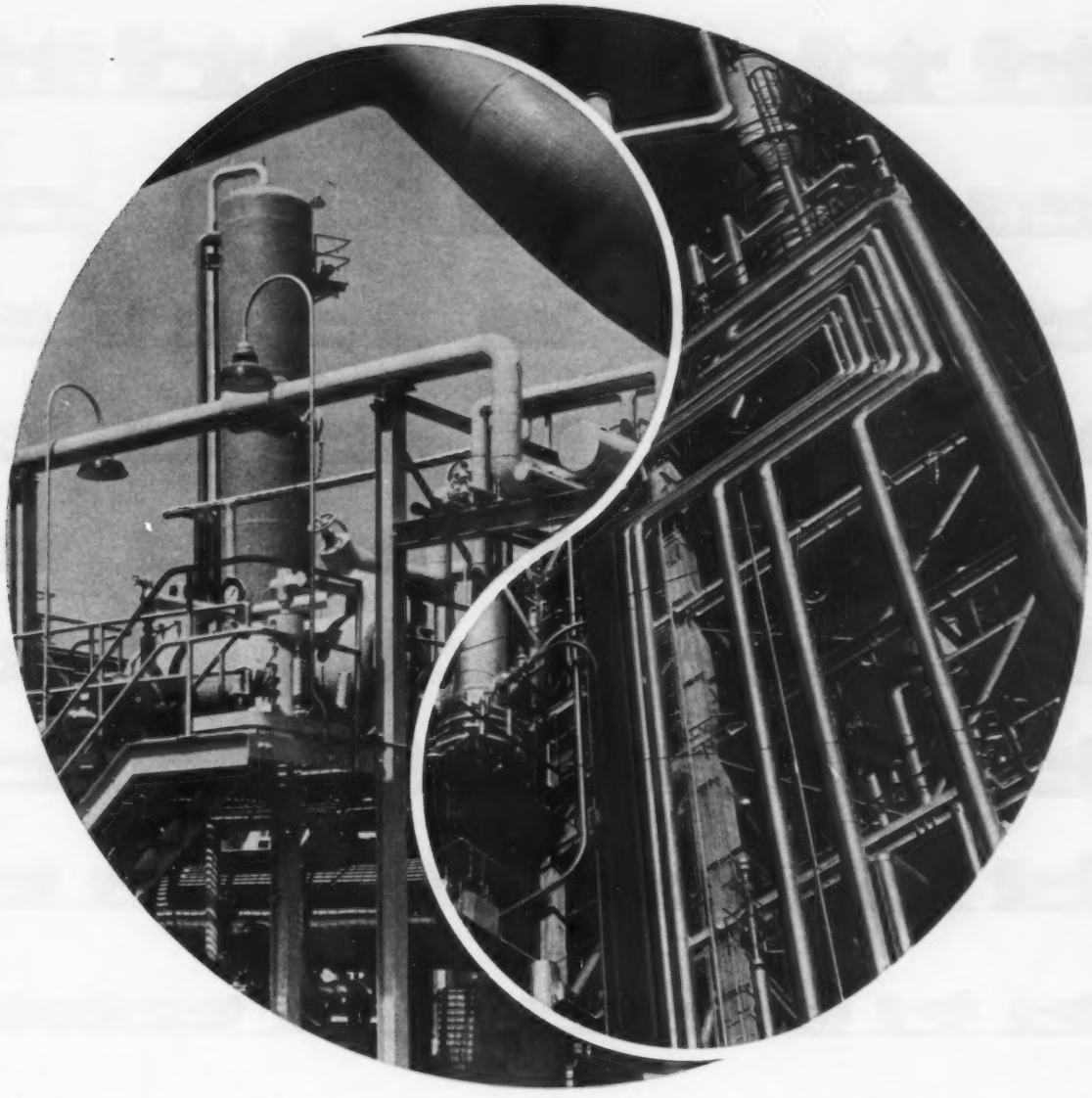
Builders of Steam Power Equipment for Nearly a Century



IN PETROCHEMICAL PROCESSING

Look to Parsons for Performance backed by experience and a long record of successful projects for the process industries. Significant contributions have been made by Parsons to development and refinement of manufacturing methods, new handling and processing techniques and equipment, and improved facility designs. Bring your engineering-construction problems to Parsons and get the benefits of total capability, single source responsibility.

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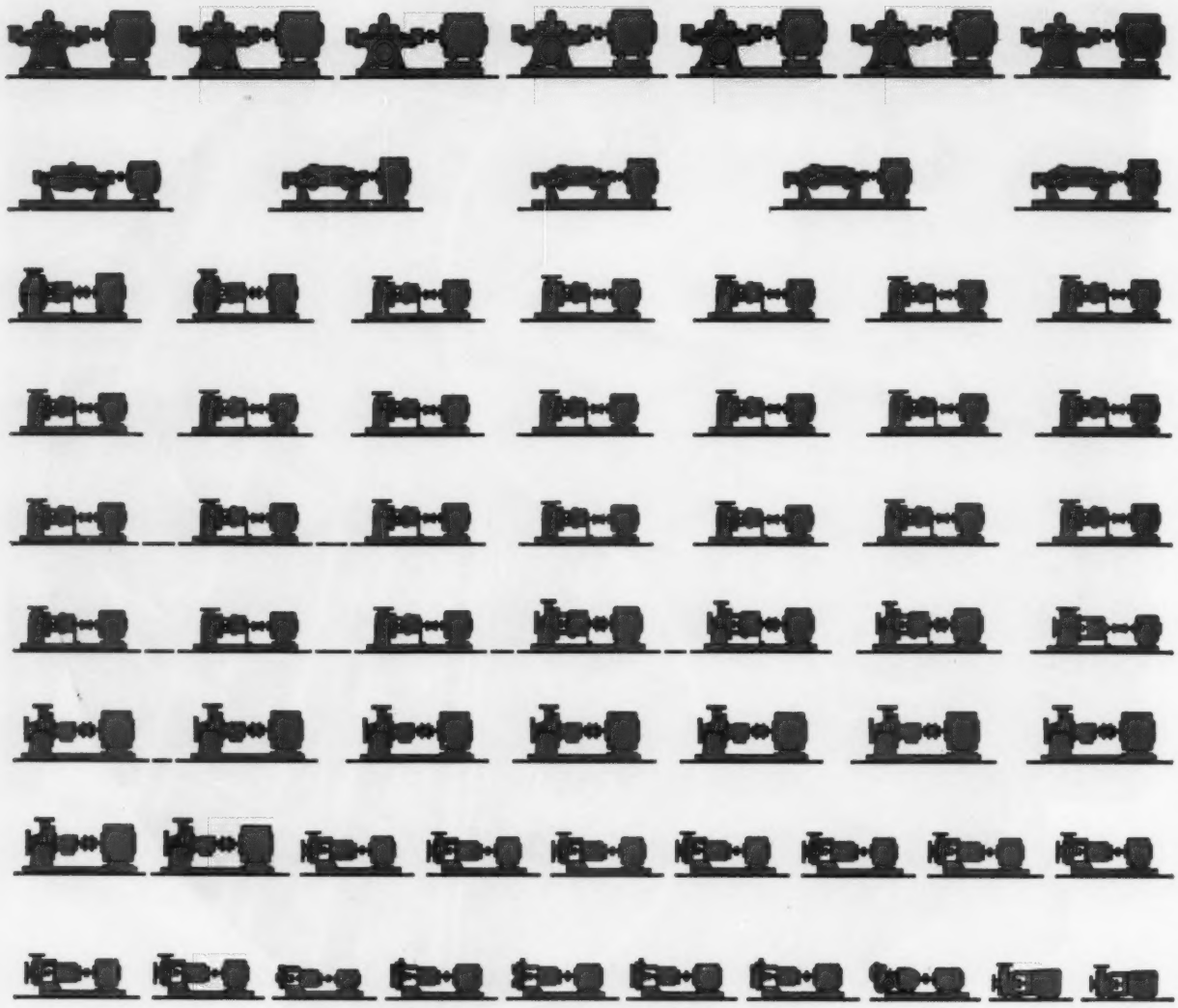
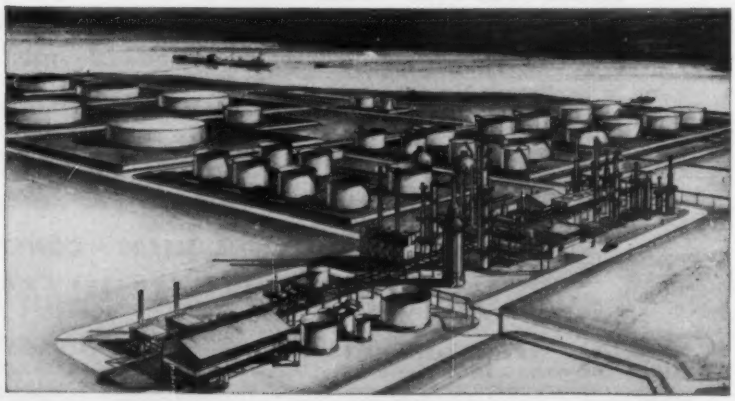
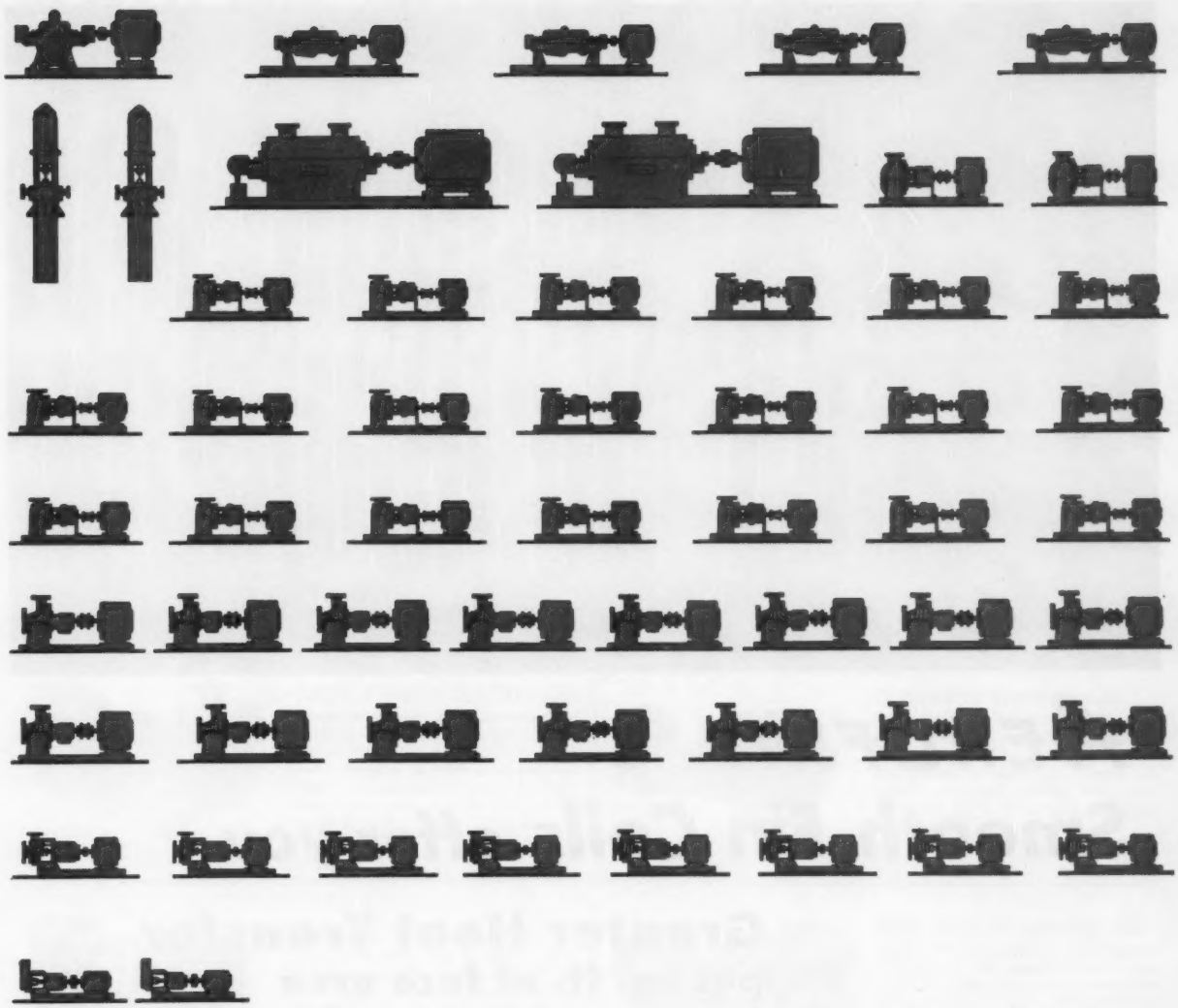


These 122 Ingersoll-Rand centrifugal pumps

at new "grass-roots" refinery





will handle a variety of requirements

in Panama

To handle 50,000 barrels of crude per day, and convert it to high octane gasoline takes a lot of pump power. In fact, at Refineria Panama, S.A., the all-new "grass-roots" refinery being designed and built by Bechtel organization for Continental Oil Company and National Bulk Carriers, Inc., it will take 122 centrifugal pumps of 51 different types and sizes—*all* supplied by Ingersoll-Rand.

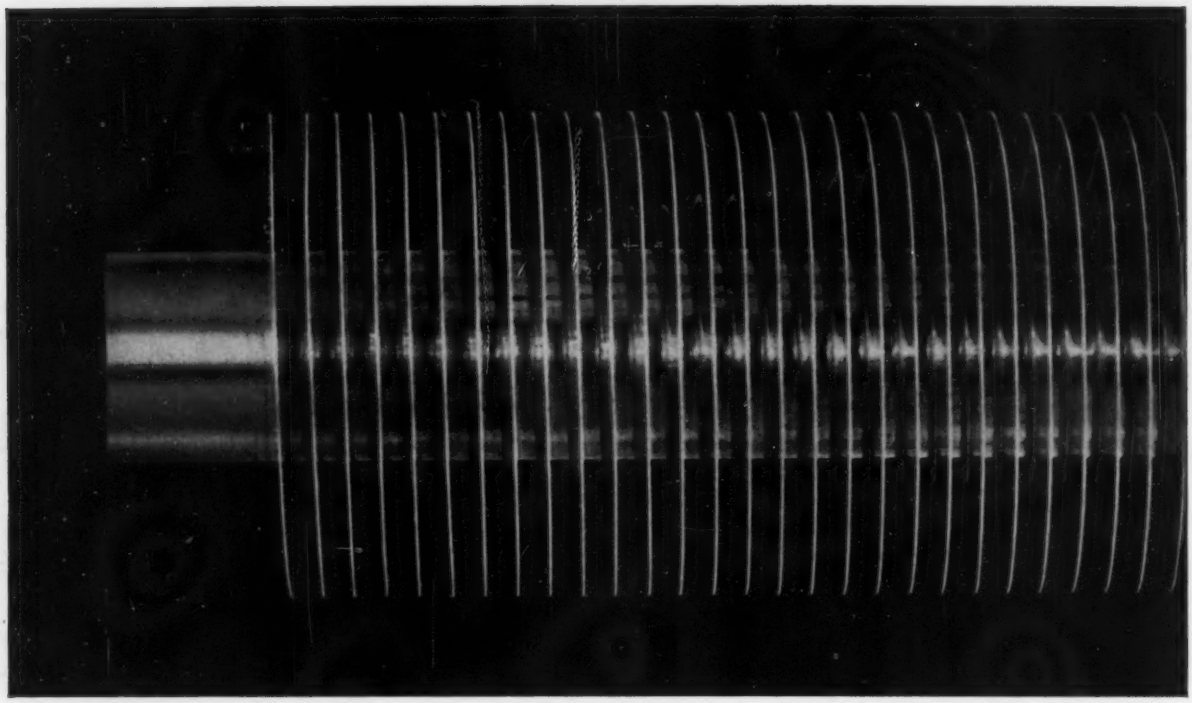
This refinery will also have four I-R reciprocating compressors for process and instrument air service and a 7-stage I-R centrifugal compressor for recycle gas compression.

Call in your Ingersoll-Rand engineer. He has the world's largest pump line and the most comprehensive compressor experience at his disposal.

Ingersoll-Rand

305A10 11 Broadway, New York 4, N.Y.

MORE THAN A CENTURY OF PUMP PROGRESS



AEROFIN
Smooth-Fin Coils offer you

Greater Heat Transfer
per sq. ft. of face area

Lower Airway Resistance
—less power per c.f.m.

Aerofin smooth fins can be spaced as closely as 14 per inch with low air friction. Consequently, the heat-exchange capacity per square foot of face area is extremely high, and the use of high air velocities entirely practical. Tapered fin construction provides ample tube-contact surface so that the entire fin becomes effective transfer surface. Standardized encased units arranged for simple, quick, economical installation.

Write for Bulletin S-55

AEROFIN CORPORATION

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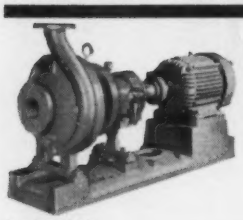
Aerofin is sold only by manufacturers of fan system apparatus. List on request.

GOULDS PUMPS, INC.

Dept. PR-111, Seneca Falls, New York, specialists in pumps

The largest plant of its kind in the world *plus* over 100 years' experience in pump manufacturing—that's what equips us to answer all your liquid-handling needs. You have a wide line of Goulds pumps to choose from. Complete details on any pump are available in the Bulletins indicated. Write for your copy.

ATLANTA • BOSTON • BUFFALO • CHICAGO • HOUSTON • NEW YORK • PHILADELPHIA • PITTSBURGH • SHREVEPORT • TULSA • REPRESENTATIVES EVERYWHERE

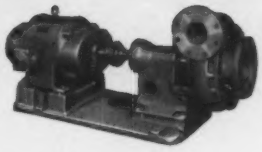


Model 3195

INTERCHANGEABLE CHEMICAL PUMPS

11 pump sizes with same overall length, 23 in. Capacities to 775 GPM, heads to 300 ft. tdh. Working pressures to 275 psig. Standard in ductile iron, 316 stainless steel, Gould-A-Loy 20. Handles liquids to 500°F. Maximum interchangeability of parts and dimensional interchangeability of models give you greatest flexibility and coverage.

BULLETIN 725.1.

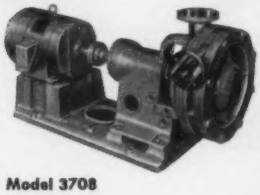


Model 3755

FRAME MOUNTED CENTRIFUGALS

Built in 24 sizes, with capacities up to 4000 GPM and heads up to 400 ft. Designed for standard electric motor drive; readily adaptable for belt drive. A substantially built line for general and special applications with many new improvements.

BULLETIN 715.1.

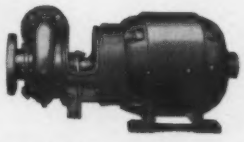


Model 3708

GOULDS-PFAUDLER GLASSED PUMP

Revolutionary new pump designed for handling corrosive liquids. All parts in contact with liquid are glass—fused to metal. Handles all acids except hydrofluoric, and all alkalies to pH 12. Four sizes, with capacities to 700 GPM, heads to 140 ft.

BULLETIN 725.2.

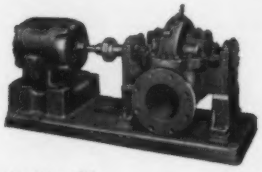


Model 3655

CLOSE-CUPLD CENTRIFUGALS

Single-stage pumps built in 23 sizes with a capacity range from 5 to 2000 GPM and heads up to 400 ft. Embody top horizontal discharge, closed impeller, machined stuffing box, fully protected shaft. Wearing parts easily renewable.

BULLETIN 710.1.

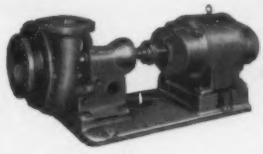


Model 3405

DOUBLE-SUCTION CENTRIFUGALS

Capacities from 100 to 6400 GPM. Heads up to 525 ft. Three shaft and rotating parts assemblies provide for 70 sizes and 140 pump combinations. Horizontally split casing.

BULLETIN 721.6.

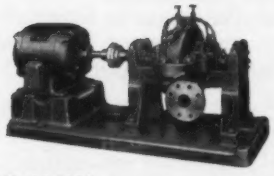


Model 3189

OPEN IMPELLER CENTRIFUGALS

Highly efficient open impeller pumps available in 13 sizes for both motor and belt drives. Capacities up to 3000 GPM, with heads up to 180 ft. at 1750 RPM. Well suited for irrigation, general industrial processes, and slurries.

BULLETIN 720.4.

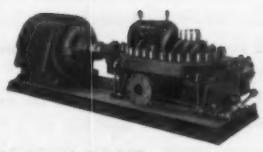


Model 3305

TWO-STAGE CENTRIFUGALS

Ten sizes provide heads up to 1000 ft., capacities to 3000 GPM, depending on heads. Horizontally split casing. Opposed impellers, with labyrinth diaphragm for maintaining thrust balance.

BULLETIN 722.6.

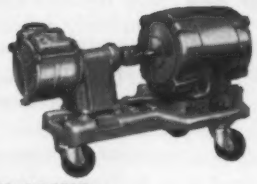


Models 3330-3360

MULTI-STAGE CENTRIFUGALS

Medium- and high-pressure multistage pumps. Model 3330 is furnished in sizes from 3 to 8 inches, 2 to 6 stages, with capacities ranging from 40 to 2100 GPM, heads to 950 ft. Model 3360 furnished in 3, 4, 6, and 8 inch sizes, up to 8 stages, with capacities ranging from 50 to 2600 GPM, heads to 3400 ft.

BULLETINS 722.1 and 722.4.



Model 2520

CENTRIPETAL SCAVENGER PUMP

Centripetal action lets it pump liquid, air, liquid *and* air. Use it for transfer, cleaning-up, or pilot plant operations. Compact, lightweight, portable. All-iron or stainless steel construction. Capacities to 60 GPM, heads to 80 ft.

BULLETIN 725.6.

MODULAR VERTICAL PUMPS

SUMP

For pit depths to 20 ft. in 6 inch increments. Both wet and dry pit types available in capacities up to 3180 GPM, heads to 190 ft. Single and duplex units. Full automatic control. Modern design using standard parts permits quick shipment at most economical cost.

BULLETIN 726.2.

PROCESS

Especially designed for handling corrosive liquids in the chemical process and allied industries. Normally supplied in 316 stainless steel constructions, but materials to suit user's requirements can be furnished on application.

Capacities to 720 GPM. Heads to 190 ft. For heavy-duty service under most severe applications.

BULLETIN 727.1.

GOULDS PUMPS

For more data on advertised products, use cards, last page.

A NEW HEAT EXCHANGER SERVICE

Preassembled Hairpins that go on Stream in Minutes

Now Brown's heat exchanger specialists furnish double pipe sections completely assembled, manifolded, and tested. Pipe up your process to a Brown section and you're ready to go!

1. New processes and revamps get on stream faster . . . pay off equipment investments sooner.
2. Experienced Brown personnel are able to assemble your sections into engineered banks of units quickly at a savings to you.
3. Preassembled Brown units assure correct manifolding, proper alignment, and faithful engineering to your requirements.
4. Factory tested Brown units drastically reduce field testing time.

If heat exchangers are in your future, save money with Brown assembled sections. Write for Brown Fintube Double Pipe Heat Exchanger Bulletins. Send request to: Brown Fintube Company, Dept. H, 300 Huron Street, Elyria, Ohio.

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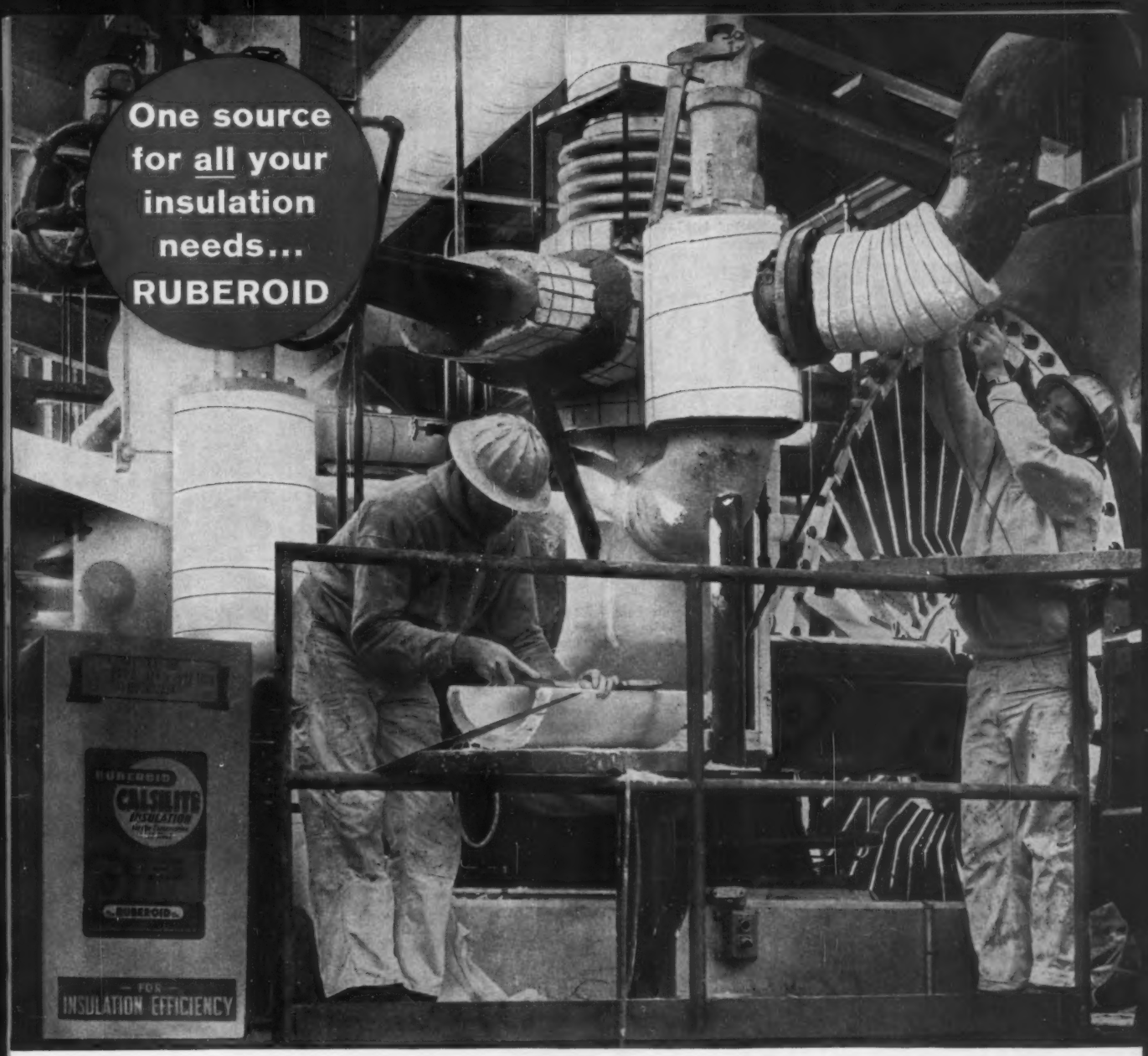

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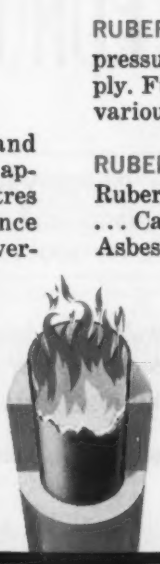

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Iron Body Bronze Trimmed Gate Valve for 125 psi—Fig. 1793. Bolted yoke-bonnet, outside screw rising stem, solid wedge, bronze seats. Available with screwed ends and in all iron.

Bronze Gate Valve for 200 psi—Fig. 375. Union bonnet, inside screw rising stem, interchangeable solid or split wedge, integral seats. Available with flanged ends.

Stainless Steel Gate Valve for 150 psi—Figs. 2453SG (Solid Wedge), 2453DG (Split Wedge). Bolted yoke-bonnet, outside screw rising stem, integral seats. Wedges are fully guided.

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Iron Body Bronze Trimmed Swing Check Valve for 125 psi — Fig. 559. Bolted flanged cap, renewable bronze seat and disc. Screwed end and all iron valves are available.

Steel Gate Valve for 300 psi — Fig. 3003. Bolted yoke-bonnet, outside screw rising stem, solid wedge, screwed-in seat rings. End flanges have 1/16" raised face. Screwed end and welding ends can be furnished.

ASA 150-pound Carbon Steel Lubricated Plug Valve — Fig. 1563G. Bolted gland type, worm gear operated. Spur gearing can be furnished. Facing, drilling and dimensions conform to latest standards.

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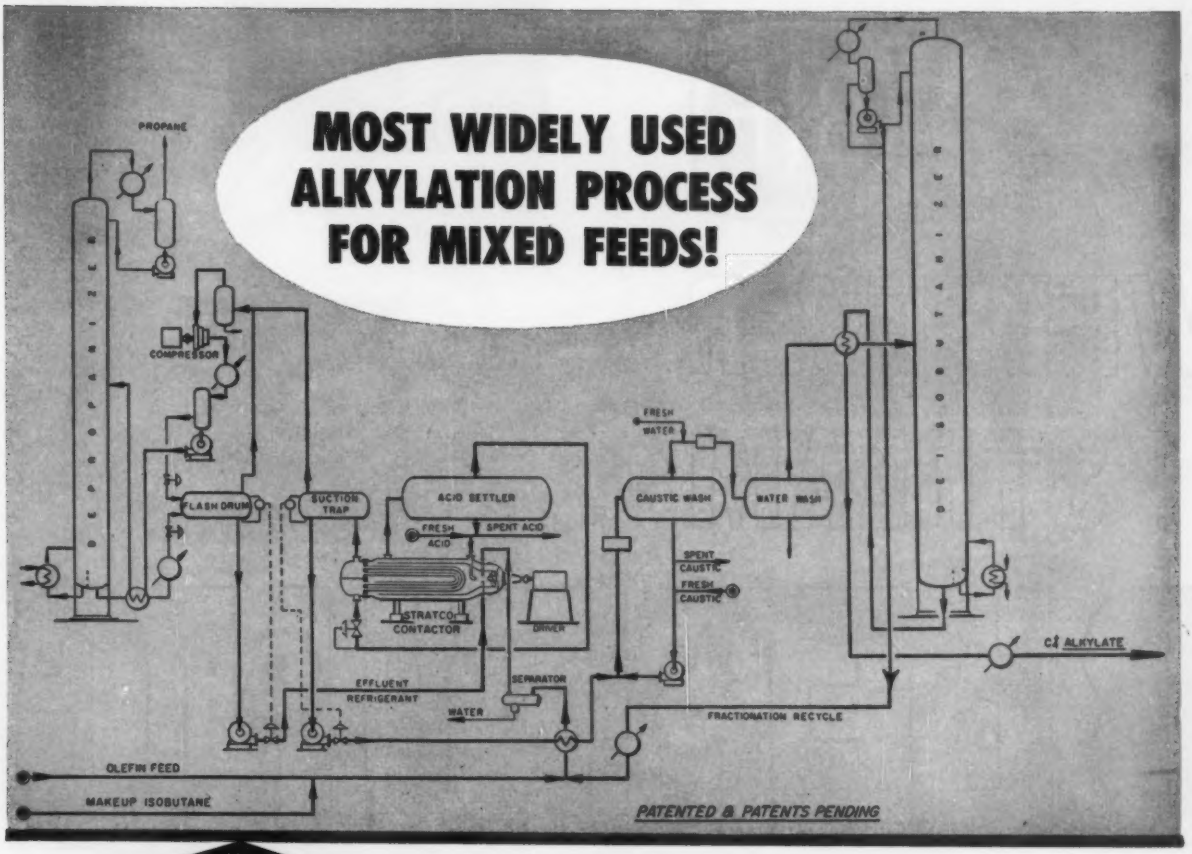

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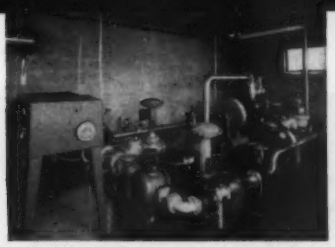
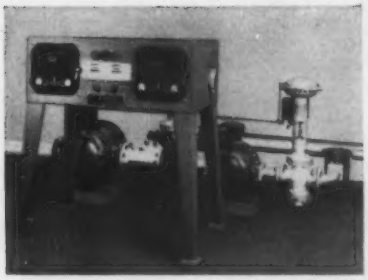
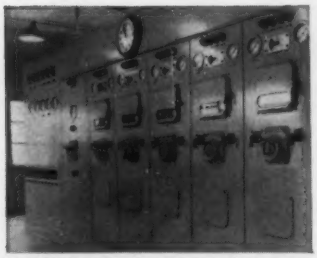


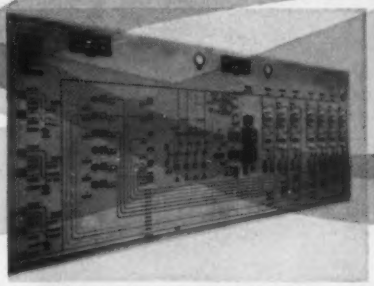
FUEL OIL Base stocks at terminals or loading racks are blended at twist of a dial . . . directly from storage to tank trucks, tank cars or barges . . . automatically, safely, accurately!



ASPHALT Penetration blends or asphalt cutbacks are continuously blended in a single-pass operation at loading racks direct to tank truck without intermediate storage and within state specification.



LUBE OIL Continuous recirculation-type fail-safe Panel Blenders . . . compound specification lubes and additives at minimum production costs . . . increase operating efficiency and formulation accuracy . . . reduce tankage.



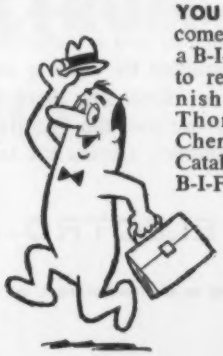
GASOLINE Explosion-proof Panel Blenders, close-coupled or remote, continuously proportion base stocks, dyes, additives, and TEL with fingertip control over any formulation in any quantity. Error-free, fail-safe operation.

ADDITIVES A complete line for automatically proportioning additives to gasoline, lubricating oils, fuels, etc.; including economical proportioning pumps and flow responsive metering systems.

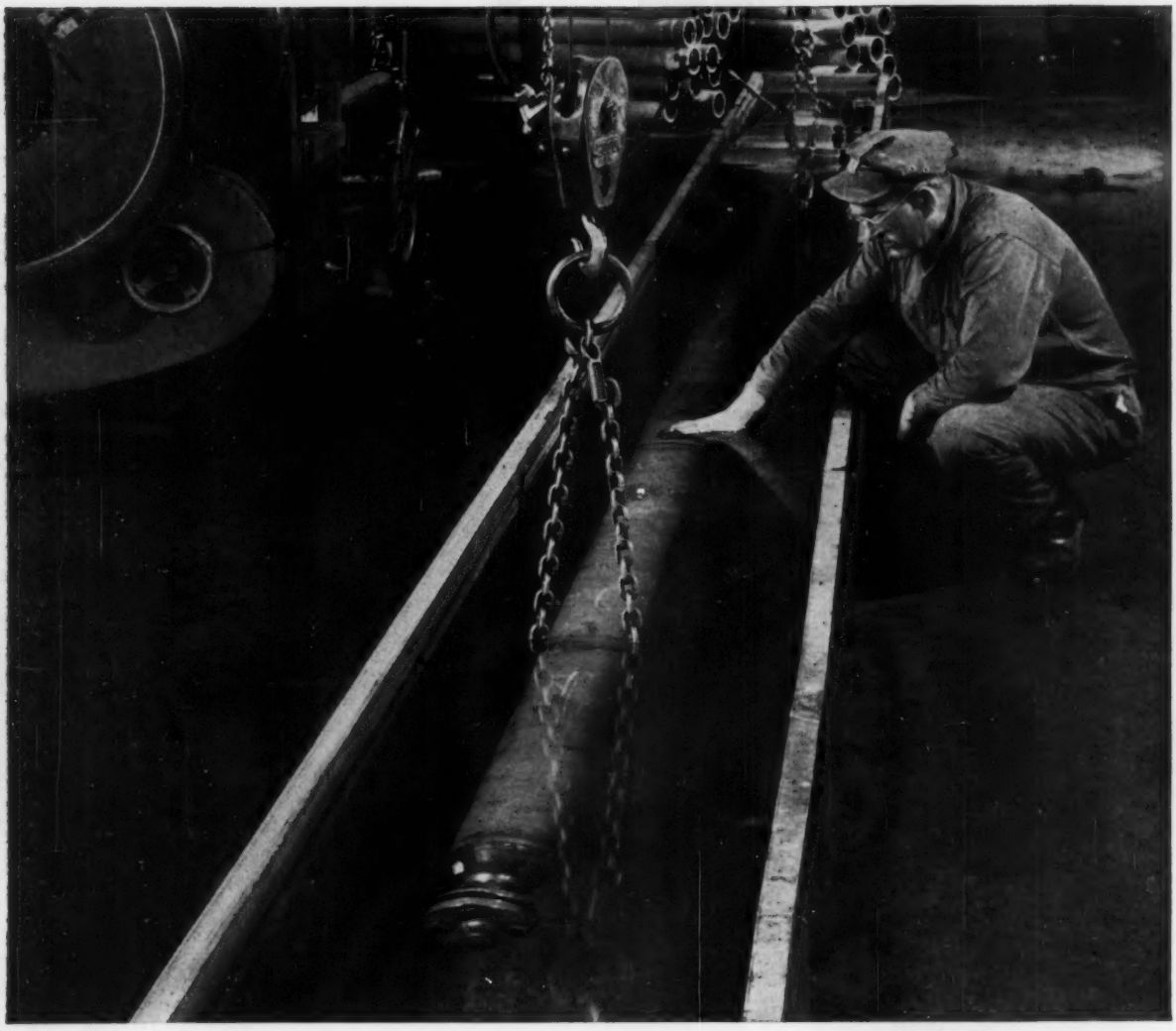
JET FUEL Automatic in-line Panel Blender . . . remote transmission . . . minimum installation cost, maximum flexibility, high accuracy, economical fingertip formulation.

BUNKER FUEL Mobile units . . . for continuous, automatic, "on-the-spot" blending of specification bunker fuels directly from base stock storage to ships' bunkers.

ELECTRONIC BLENDING In multicomponent blending systems, the B-I-F Electronic Console provides remote operation with maximum control in minimum space at minimum cost. Entire blending operation, supervised by a single qualified technician, effectively provides "Laboratory Control" of entire operation. Is applicable in the gasoline, lube oil and jet fuel operations illustrated above.



YOU NAME IT! When it comes to stream blending, a B-I-F specialist is ready to recommend and furnish estimates. See Thomas Register or Chemical Engineering Catalog for your nearest B-I-F representative.



Air Pressure—Just one of seven tests on Reformer Tubes before they leave Electro-Alloys

It takes seven thorough inspections to assure you leakproof service . . . and each of our tube assemblies goes through them all. The air inspection shown above tested these tubes underwater at 100 psi.

At the beginning of the test series, each tube section receives an *air test* and a *hydrostatic test*. Then the tubes are assembled by welding and each weld checked three ways—*Borescope*, *Dyckek* and *X-ray*. We repeat the *air* test and the *hydrostatic* test with the complete assemblies. During the test series and at the end of it, there is careful visual inspection by experienced personnel.

A *chemical analysis* assures composition control when the tubes are cast. All this adds up to positive protection against costly leaks.

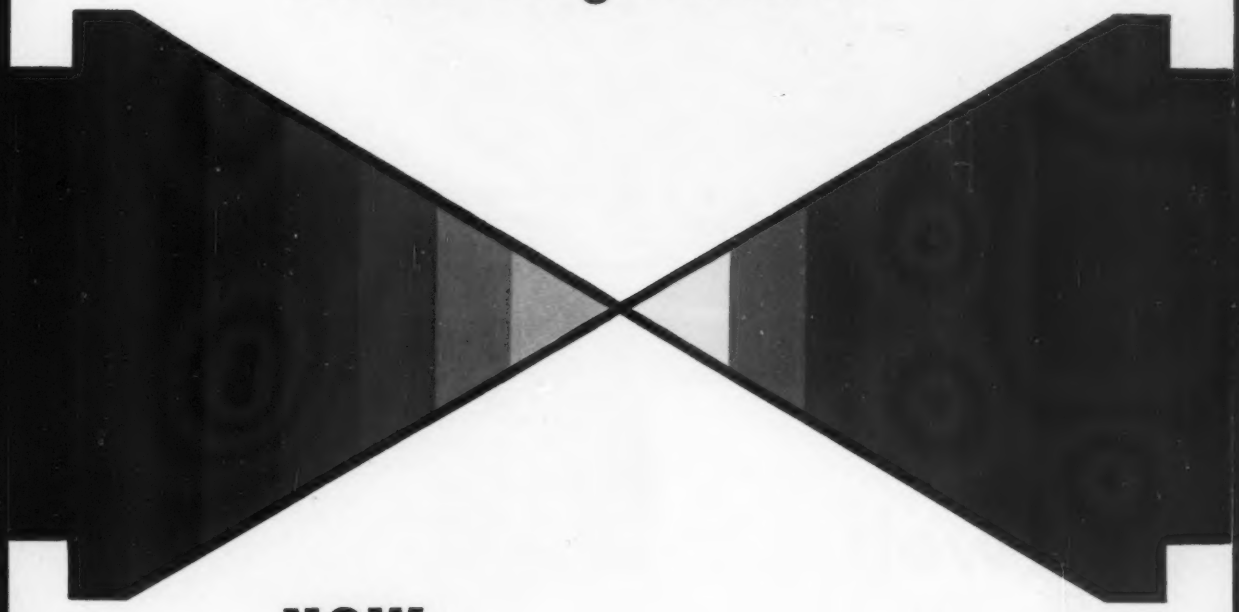
For reformer tubes that provide leakproof service, specify Electro-Alloys centrifugally cast tubes . . . backed by years of casting experience.

Call your nearest representative or write: Electro-Alloys Division, American Brake Shoe Company, 30211 Taylor St., Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

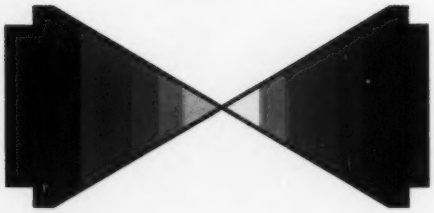
ELECTRO-ALLOYS DIVISION · Elyria, Ohio

Some valves are designed
for the easy services...
the others,
for the tough ones...

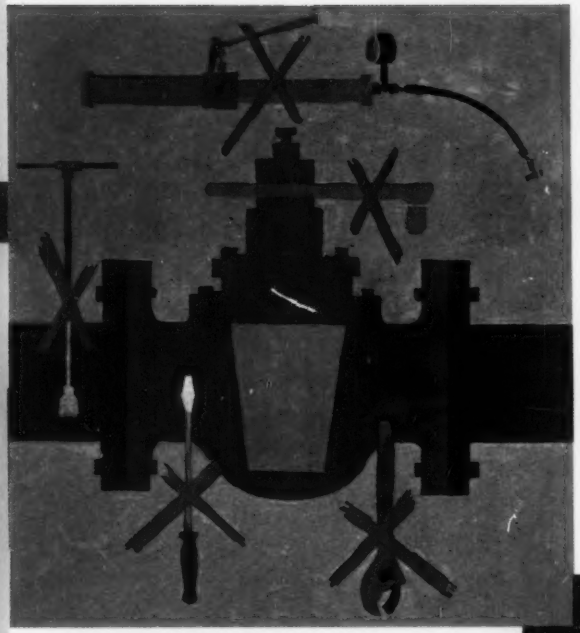


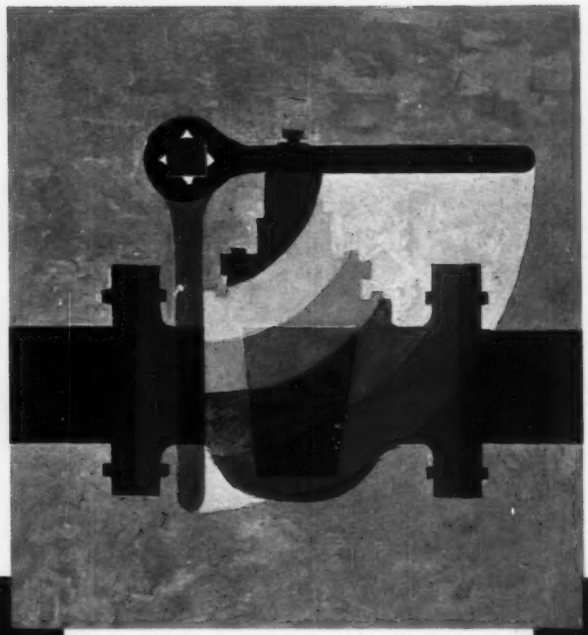
NOW,
ROCKWELL HAS DEVELOPED
AN EXCITING, NEW
CONCEPT THAT
SPANS THE SPECTRUM
OF VALVE SERVICES

THE NEW ROCKWELL PERM



Now, in one valv
for versatile appl





Attention-Free Performance

Some valve users put a premium on a valve that can be installed and forgotten —that needs no attention. For many non-critical services, this kind of valve is adequate: the new Rockwell PERMATURN valves can be used in such services with no attention—and with excellent results.

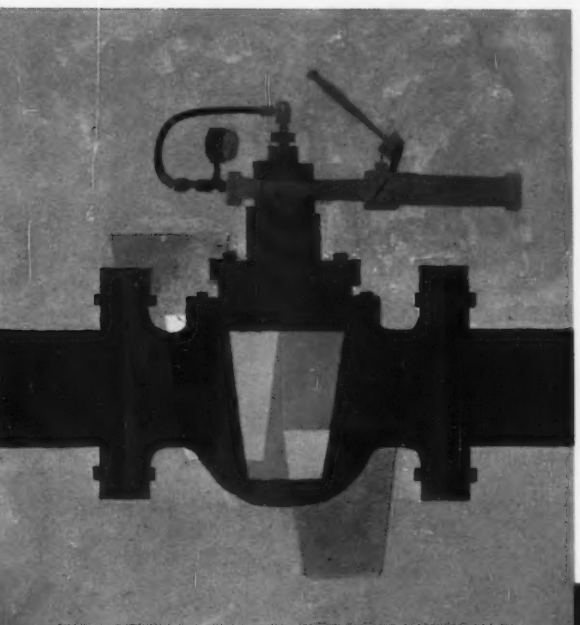
Easy 90°-Turn Operation

Fast opening and closing are easier with the new Rockwell PERMATURN than with any other valve ever developed. Just a quick, smooth quarter-turn from full-open to shut-off, and this unique valve design assures low-torque operation always—that's where the name PERMATURN comes from!

LIFT THESE PAGES for more information on this exciting new valve line!

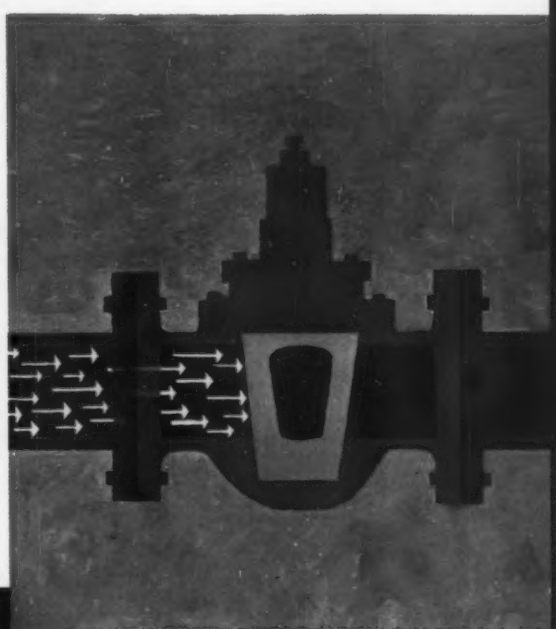
RMATURN® VALVE DESIGN!

lve, you get all the features needed pplication to any fluid control service



Push-Button Seat Replacement

Here's a feature you'll find in no other type valve: you can put a new seating surface in the new PERMATURN valve in seconds, *without loosening a single bolt.* You can replace valve seats as often as you like—no more putting up with leaky valves. You add years of life—and save money—with this performance-extending feature of PERMATURN valves.



Drop-Tight Sealing

There are some valve applications where there's just no substitute for the bottle-tight, wear-defying characteristics of the new Rockwell PERMATURN valve used with a *regular program of sealant replacement.* And in these critical services, the PERMATURN valve has dramatically reduced operating torque requirements.

!

THE NEW ROCKWELL PE

available in all sizes f

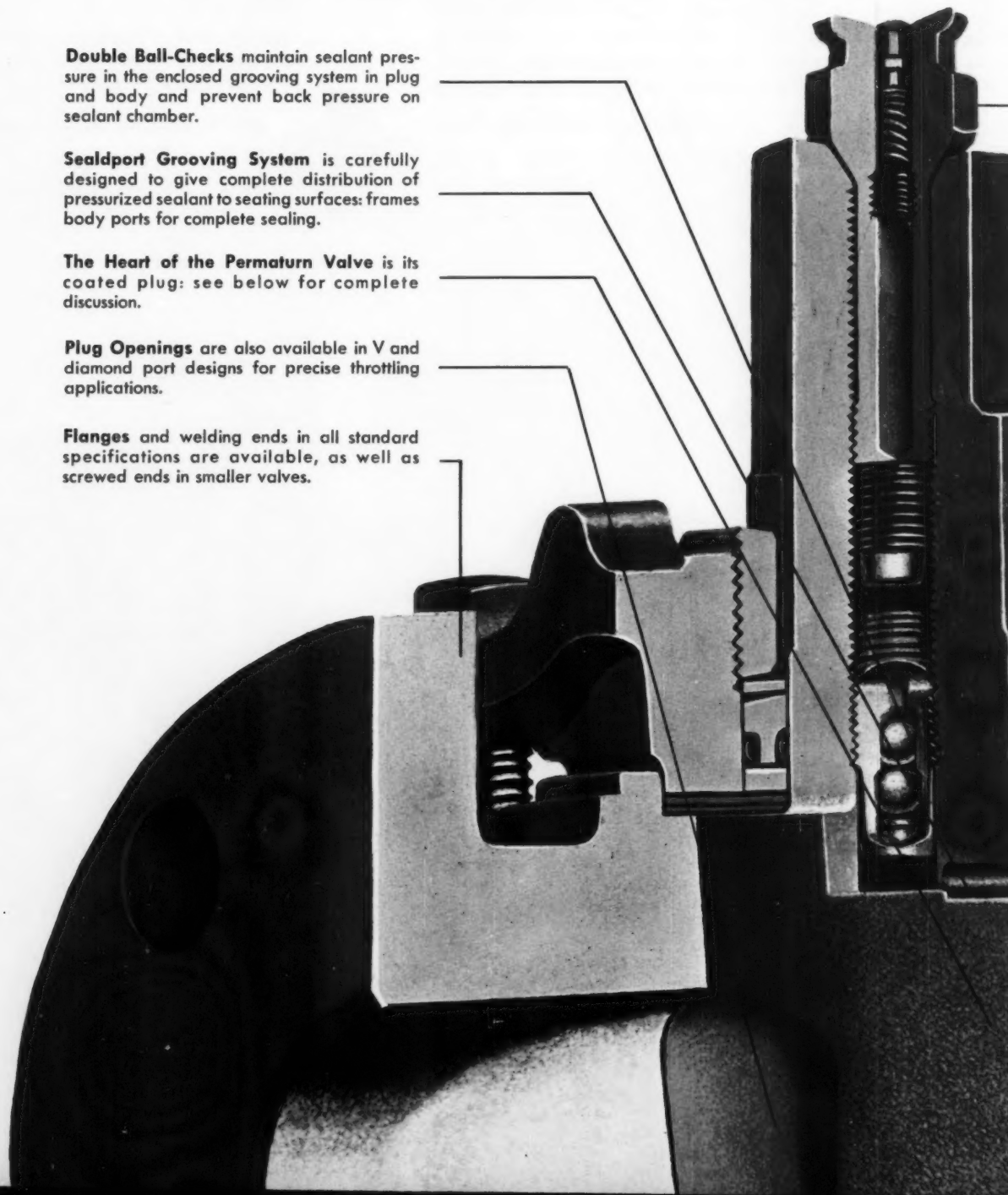
Double Ball-Checks maintain sealant pressure in the enclosed grooving system in plug and body and prevent back pressure on sealant chamber.

Sealdport Grooving System is carefully designed to give complete distribution of pressurized sealant to seating surfaces: frames body ports for complete sealing.

The Heart of the Permaturn Valve is its coated plug: see below for complete discussion.

Plug Openings are also available in V and diamond port designs for precise throttling applications.

Flanges and welding ends in all standard specifications are available, as well as screwed ends in smaller valves.

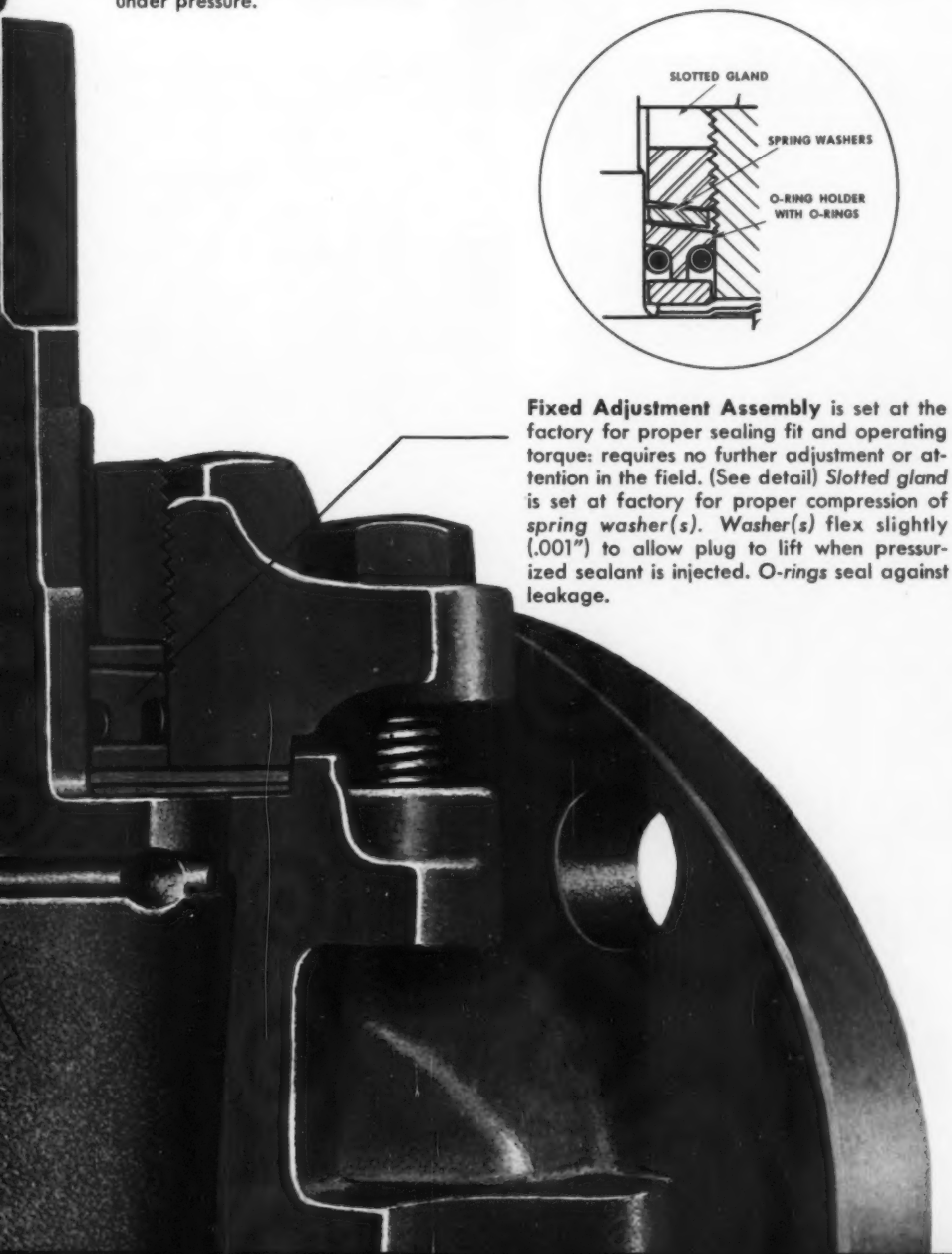


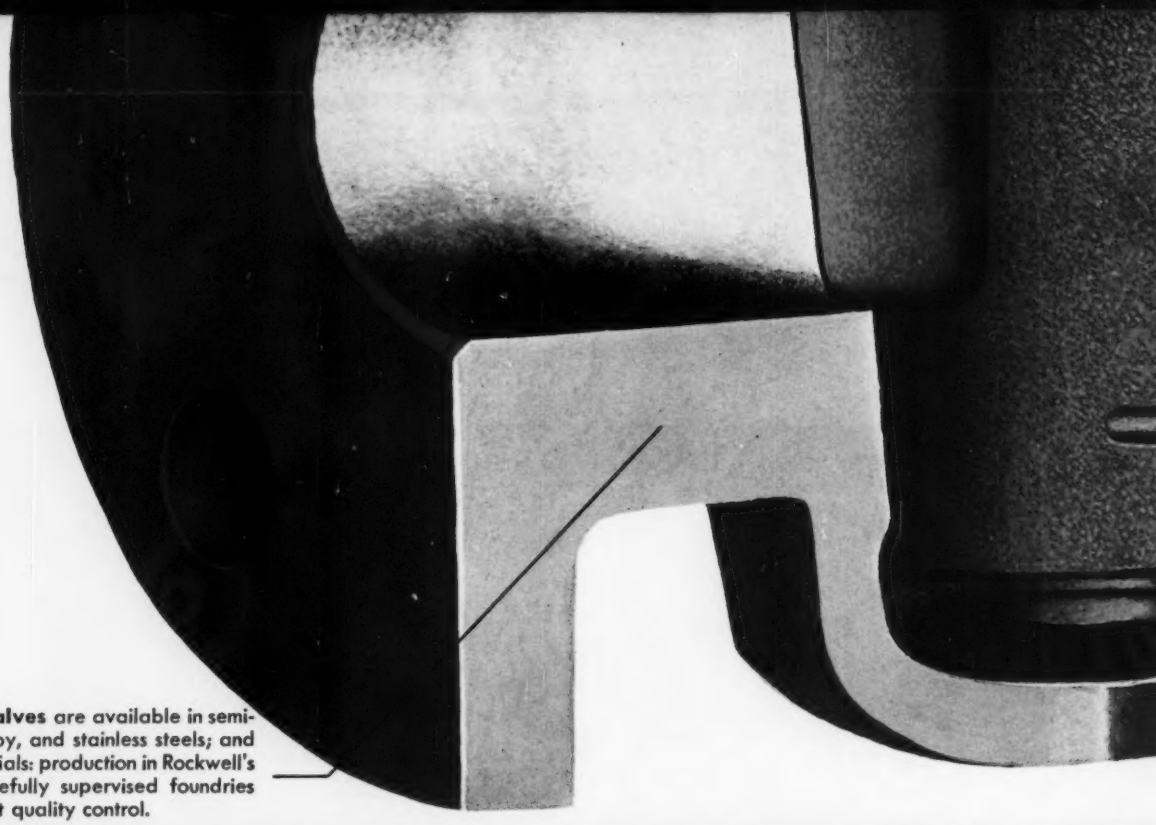
PERMATURN® VALVES

for all pressures

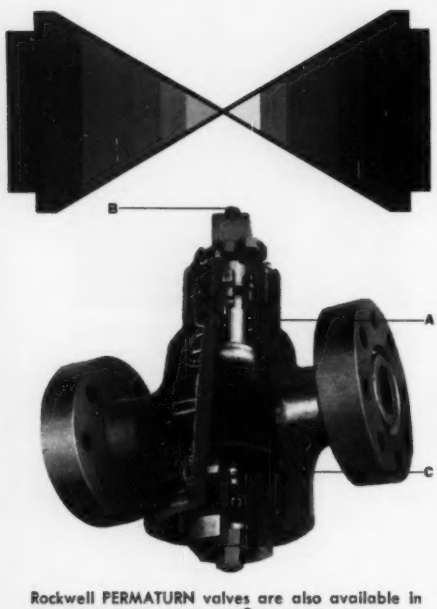
Button-Head Fitting provides for simple, quick injection of plastic sealant into PERMA-TURN valves for instant seat replacement. Fitting also serves as compression screw when sealant is used in stick form: can be removed under pressure.

Fixed Adjustment Assembly is set at the factory for proper sealing fit and operating torque: requires no further adjustment or attention in the field. (See detail) *Slotted gland* is set at factory for proper compression of *spring washer(s)*. *Washer(s)* flex slightly (.001") to allow plug to lift when pressurized sealant is injected. *O-rings* seal against leakage.





PERMATURN Valves are available in semi-steel; carbon, alloy, and stainless steels; and non-ferrous materials: production in Rockwell's own modern, carefully supervised foundries provides excellent quality control.



Rockwell PERMATURN valves are also available in the inverted plug Hypreseal® design for high pressures. Low torque operation is assured by plug coating of high lubricity and bearing-guided stem. Other features are plastic stem sealing (A), fitting for "push-button" seat replacement (B), and thrust assembly (C) for controlled plug adjustment.

The secret of the Ro

PERMATURN® valve's ve

The unique design feature that makes the Rockwell PERMATURN valve line applicable to all valve services is its coated plug.

Developed after five years of extensive testing, the coating has an extremely low coefficient of friction and is applied in such a way that it is *permanently bonded to the metal surface of the plug*. This tenacious lubricating film gives *permanent separation of metal surfaces* of plug and body: the valves literally cannot stick or freeze.

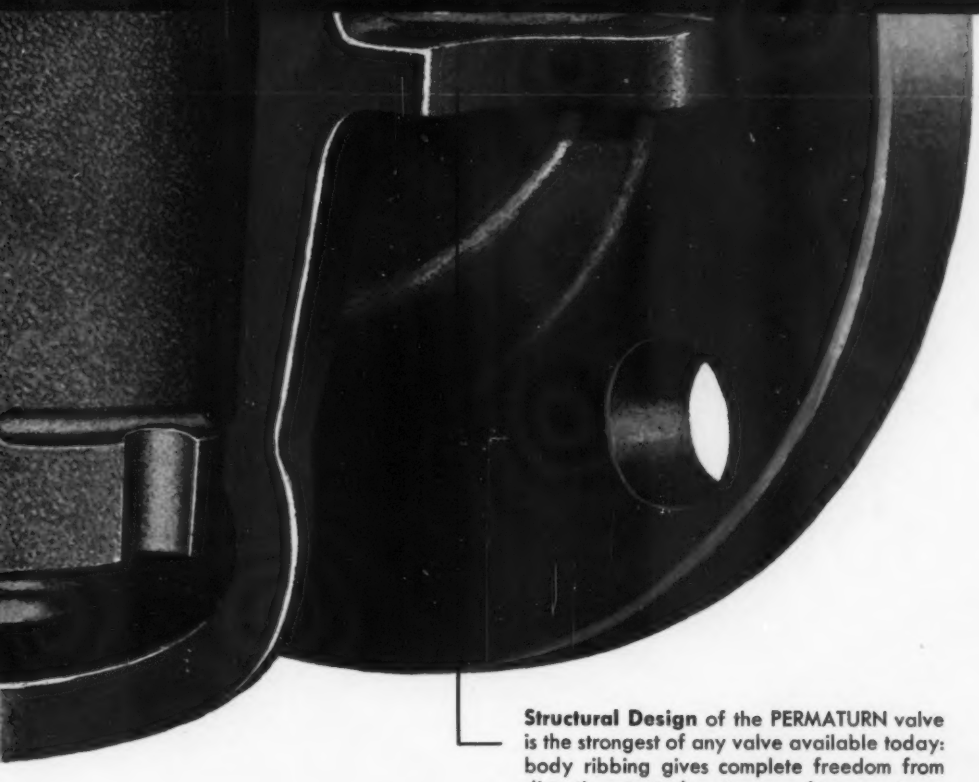
The inert nature of the plug coating assures permanent lubricity for easy, sure operation of the PERMATURN valve at all times. Combined with the many other new design features described above, the plug coatings valve these versa

Attention-Free fluids handled d

Easy, 90°-Turn even where rem tion are involved

"Push-Button" usefulness withou

Drop-Tight Sea this feature is



Structural Design of the PERMATURN valve is the strongest of any valve available today: body ribbing gives complete freedom from distortion at rated pressures and temperatures.

ockwell
ersatility...

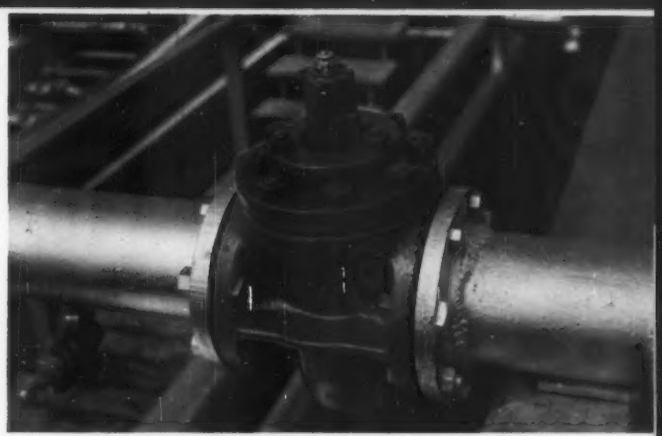
ings give the Rockwell PERMATURN
ersatile application benefits:

Free Performance in services where
d do not require a special valve.

urn Operation in all valve services,
remote operation or infrequent atten-
lved.

n" Seat Replacement extending valve
thout costly downtime and maintenance.

Sealing for critical applications where
is all-important.

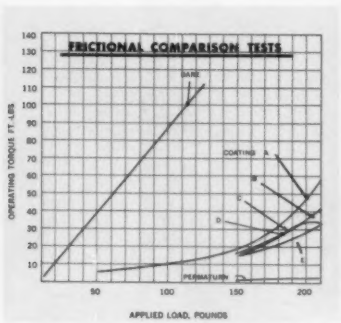


Rockwell semi-steel PERMATURN valves are shipped with a distinctive red primer paint that has wide compatibility.

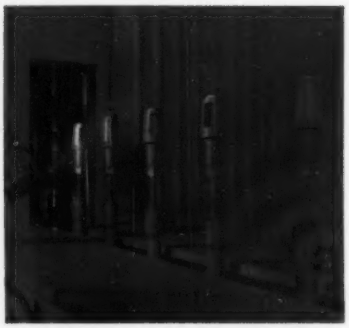
Steel PERMATURN valves are given a gray prime coat: both colors give good corrosion-protection in storage and in service.

Only Rockwell, world leader in valve research, could have developed the **PERMATURN®** valve

For more than forty years, Rockwell has pioneered in valve research. This background of experience, which made the Rockwell-Nordstrom lubricated plug valve the world's standard of quality, led to the five year development program on the PERMATURN valve, a new concept in versatile, all-purpose valve design.

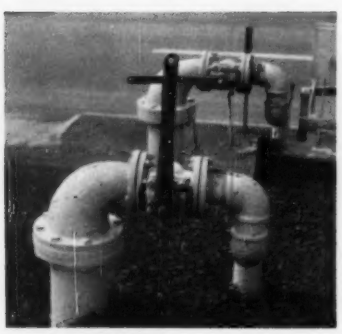


Part of this study concerned the various characteristics of many compounds considered for the plug coating medium. Exhaustive mechanical and chemical resistance tests, and carefully measured frictional comparisons, led to the selection of a material which has proved its ability to stand up under tough service for years of normal valve operation.



Complete production facilities for the new PERMATURN valve have been installed at Rockwell's nationwide valve manufacturing plants. The equipment shown above was specially developed to coat the plugs of Rockwell PERMATURN valves on a production line basis and is typical of installations at other Rockwell plants.

Rockwell PERMATURN® valves have been customer-proved before introduction



NO ATTENTION has been given these Rockwell PERMATURN valves on hydrocarbon service in the year and a half since their installation. Operation is positive and easy—and shut-off is still as bottle-tight as the day the valves were installed.

JET FUEL is handled by these Rockwell PERMATURN valves, in service since 1960. Operators have found the plug coating of PERMATURN valves gives smooth, easy operation—and has reduced sealant injection needs from once-a-week to once every three months.

SURE OPERATION on tough services has been proved by pilot installations of PERMATURN valves across the country. The coated plug supplements a regular program of sealant replacement, needed in these services for long valve life, to assure low-torque operation at all times.

Rockwell Manufacturing Company
Pittsburgh 8, Pennsylvania

I'd like to have your "Pocket Valve Guide" with brief specs and coverage charts on Rockwell PERMATURN valves.

Name_____ Title_____

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Truck (180 drums)	18,000	Amorphous Powder	9.00
55 Gal. Drum	100	Amorphous Powder	14.00
55 Gal. Drum 10 drums	1,000	Amorphous Powder	13.00
55 Gal. Drums 50 drums	5,000	Amorphous Powder	11.75
Tank Car 8,000 gals.	11,200	SWS	7.50
Tank Wagon 3,000 gals.	4,200	SWS	11.00
Truck Load 50 drums	3,600	SWS	11.50
55 Gal. Drum 1 drum	72	SWS	13.00
55 Gal. Drums 10 drums	720	SWS	12.50

*PRICES, subject to change without notice. Prices are domestic and include a license to practice the inventions in the claims of one or more of the following U. S. Patents: 2,683,721; 2,925,441; 2,925,438; 2,925,437; 2,856,428; 2,942,990; 2,930,770; 2,930,771; 2,951,819.

PIONEERS IN HYDRIDE CHEMISTRY

M H I *Metal Hydrides Incorporated*

607 CONGRESS STREET,
BEVERLY, MASSACHUSETTS

Please send me complete information about how sodium borohydride fits profitably into our processing picture.

Our products include: .....

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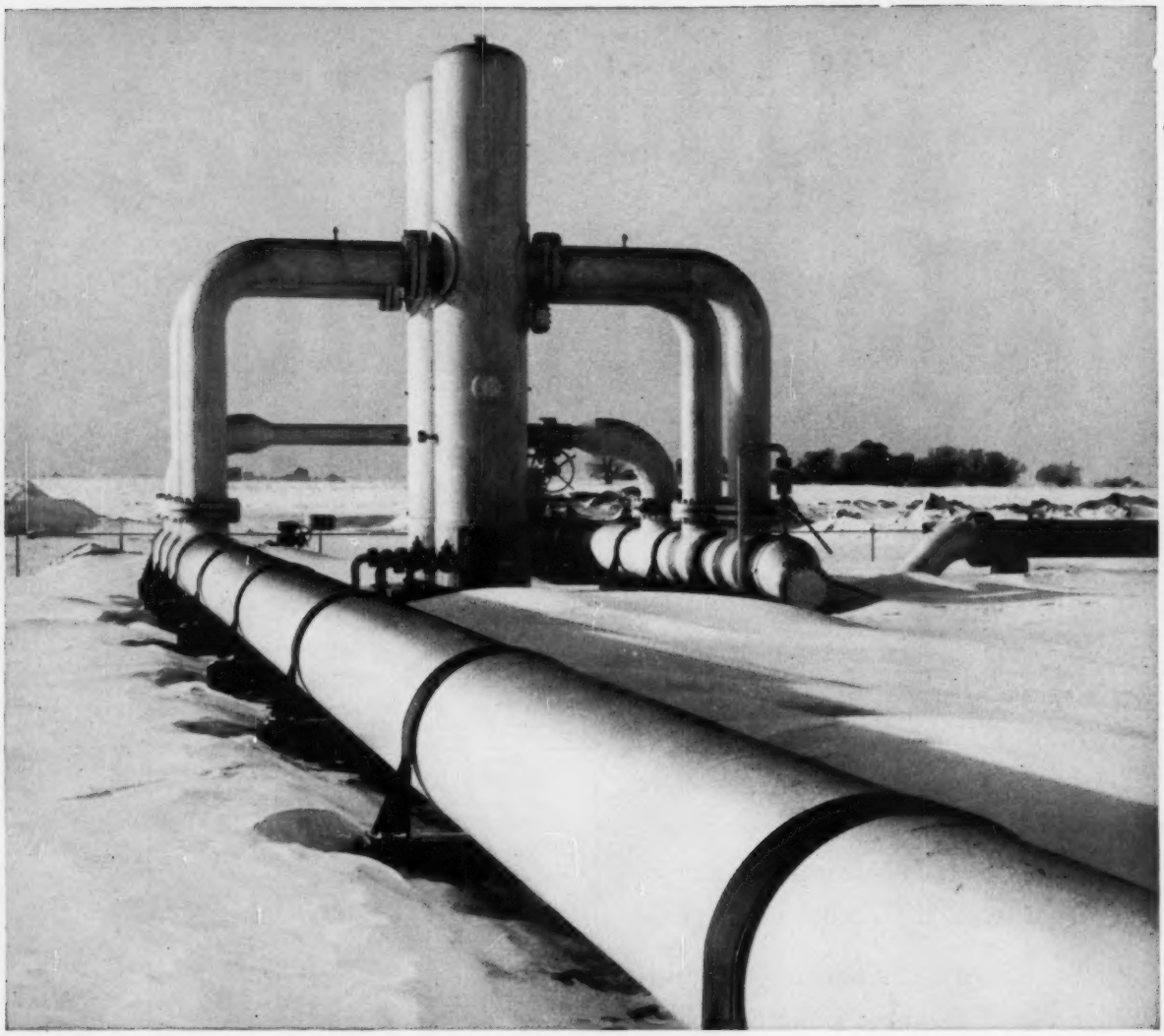
Street .....

City ..... Zone ..... State .....

☐ **Check Here If You Want General Technical Data Sheets Only.**



HOW TO SCRUB GAS AT MINUS 40° F

This is part of the Trans Canada Pipe Line which stretches from Alberta's eastern border all the way to Montreal. Keeping natural gas *clean* and *moisture-free* as it moves along the 2,340-mile length is a big job, especially when temperatures drop to 40° below zero.

But even these unusual requirements are no problem for AAF. Six big AAF Amerclone gas scrubbers are now at work on the Trans Canada Pipe Line. One hundred 4½-inch Amerclone tubes in each scrubber maintain high collection efficiency year 'round . . . dust particles simply drop from the tubes to a hopper at the bottom. These AAF units are capable of handling 400 MMSCFD at a pressure of 850 psi—and are among the largest ever installed in Canada.

Whether your operation is in an arctic, desert or temperate region — whether your application is pumping, process, or power — AAF can help you with your air- or gas-cleaning problem. Get complete information from your nearby AAF representative; or write us direct. Address: Robert Moore, American Air Filter Company, Inc., 452 Central Avenue, Louisville, Kentucky. In Canada: American Air Filter of Canada, Ltd., 400 Stinson Blvd., Montreal 9, Quebec.

AAF **American Air Filter**

BETTER AIR IS OUR BUSINESS

Photographed at DX Sunray, (Tulsa Refinery)

For higher yield... new Aerocat 3C

CAN YOU USE a higher yield of gasoline—? or of propylenes or butylenes—? Then investigate the new AEROCAT 3C! It's a new fluid cracking catalyst composition, developed by Cyanamid in cooperation with a major oil company. AEROCAT 3C-12 gives increased gasoline yield . . . AEROCAT 3C-20, increased propylene and butylene yields . . . both at the expense of dry gas and coke.

In actual commercial operations, these new three-component catalysts have proved their ability to provide refiners with more flexible, more profitable operation. They are highly active, exceedingly stable, and completely operative.

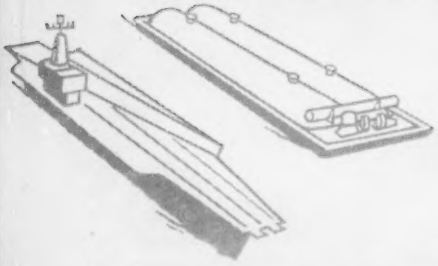
Your "Man with the Golden Rule"—your Cyanamid salesman—will be glad to work with you to determine the suitability of AEROCAT 3C for your needs. He knows catalysts—and behind him are the resources of a major producer of both catalysts and other chemicals. Why not call him now?

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • Bound Brook, New Jersey

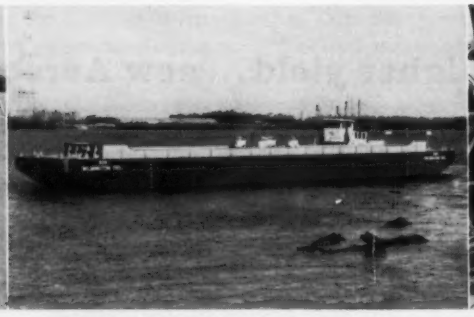
Avondale 600-ton lift lowers 242' O.A. by 16' O.D. tank into position on Phillips Petroleum Company barge. This unit, one of two refrigerated propane-ammonia barges building for Phillips Petroleum, are the largest tank carriers yet to be constructed for the chemical or petrochemical industry for this type service. The heavily insulated tanks will carry 1700 tons of anhydrous ammonia, refrigerated to minus 28 degrees F., by equipment installed on the barge.



AVONDALE BARGES

SUPER CARRIERS WITH A DIFFERENT MISSION

This liquid chlorine carrier was built by Avondale for Monsanto Chemical Co. and measures 195' x 35' x 11'. It contains six tanks, each 8'8" O.D. x 70'0" in length. The capacity of this barge loaded is 900 tons of liquid chlorine.



Liquid chlorine is being transported by this 175' x 26' x 11' cargo barge for the Diamond Alkali Company. Four independent tanks were mounted on saddles and retained by adjustable 3" x ⅛" flatbar straps.

Hull of Phillips Petroleum barge ready for launching at Main Yard. Hopper design accepts two saddle-mounted tanks. The lead barge measures 305' x 44' x 12'6", the trailing barge 284' x 44' x 12'6". The pair are designed to be handled either independently or as an integrated tow.

Spread on these pages you will see a portion of the ever-increasing Avondale-built barge fleet—*carriers with a different mission.* They're big, they're specialized—they're *super* carriers—custom-built for the chemical and petrochemical industries.

Avondale is admirably suited for complete responsibility in this type construction. Fabricating facilities include the largest and most progressive shipyard on the lower Mississippi, a complete foundry, and the finest technical know-how in the business.

Our best references include a long list of the most-respected names in the chemical and petrochemical industries.

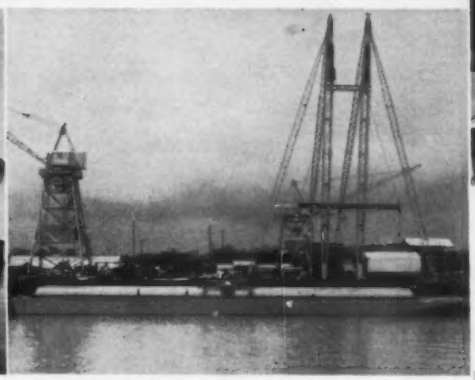
We would welcome the opportunity to quote *your* company in regard to its specialized barge requirements.

Largest cold steel plate roll of its kind in the Gulf South. This Bertsch roll in the Tank Shop has a capacity of 4½".

Specialized tank fabricating facilities. Foreground; tank nearing completion on aligning platten, left background; tank being stress relieved in Avondale 18' x 18' unlimited length stress-relieving furnace.

Tank and pressure vessel sections are welded together automatically on powered rolls in the Tank Shop.

In service for a chemical transporting company. Liquid caustic soda tank barge. Capacity 1682 tons. Size: 205' x 40' x 11'.



One of two independent pressure tank barges completed for Union Texas Natural Gas Corporation. Each barge measures 273' x 41' x 12'6". Each barge contains four cargo tanks 112' in length, each tank with a capacity of 165,000 gallons, for a total barge capacity of 660,000 gallons.

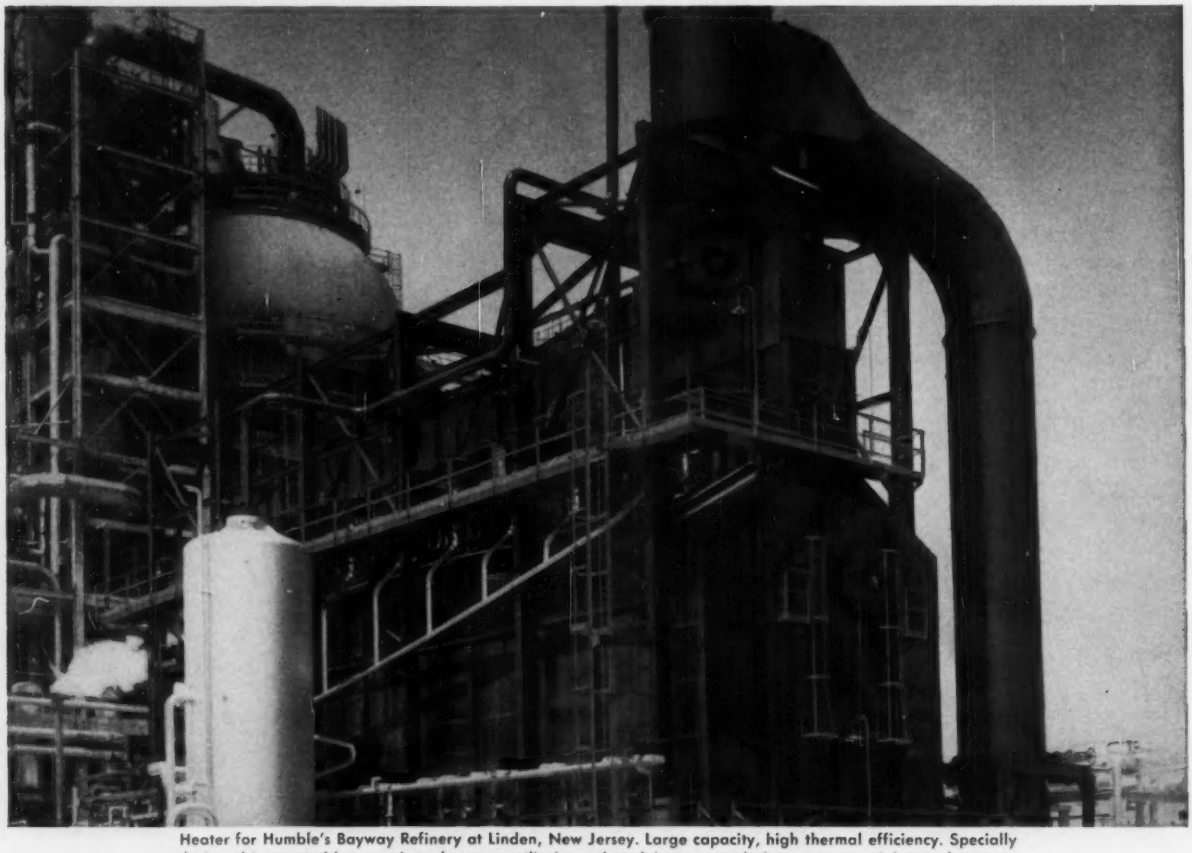
Facilities to build, and facilities and capacity to move and lift—Avondale has both. The 600-ton lifting device lowers a 242' tank.

AVONDALE SHIPYARDS, INC.

P. O. BOX 1030 • PHONE UNiversity 6-4561 • NEW ORLEANS 8, U.S.A.

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY



Heater for Humble's Bayway Refinery at Linden, New Jersey. Large capacity, high thermal efficiency. Specially designed integrated heater, air preheater, auxiliaries and stack in compact design to occupy minimum plot space.

Lummus Oil Heater for Humble's Bayway Refinery meets three tough design requirements

LARGE CAPACITY, HIGH EFFICIENCY, LONG RUNS

Humble Bayway knew exactly what they wanted in a replacement heater and turned confidently to Lummus to meet their difficult design requirements.

First, the heater had to be large enough to service this giant Cat-Cracker; now one of the largest in operation.

Secondly, Humble wanted a high thermal efficiency, 86% as compared with the usual 75-80%. In the Lummus design, the heater utilizes Ljungstrom Air Preheater and integrated blower and duct system to attain high thermal efficiency. Operating performance has been consistently high. Humble's big fuel savings have more than made up for the slightly higher capital investment for air preheat equipment.

Finally, there was one other difficult design condition. The new heater would be required to operate for long periods without shutting down for maintenance or cleaning. The Lummus design included steam soot blowers which have kept both the bare tubes and studded tube in the convection section clean. The heater fires on heavy residual fuel oil having a very high solids content.

Lummus designs horizontal and vertical tube oil heaters to any size from 100,000 to 300,000,000 BTU/Hour for any process, anywhere in the world. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right* unit for your needs. Consult with Lummus on your next oil heater—large or small.

THE LUMMUS COMPANY, Oil Heater Division, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Newark, N. J.

High assay, *Wide* usage and *Handsome* economy

that's *fmc* 97% BaO!

Now consistently assaying a remarkably high 97% minimum, FMC BaO provides a dependably pure source of barium values in a highly reactive form.

And since assay is the only thing that's up, additive makers can produce better-than-ever barium based products more economically-than-ever. Get more barium values per pound and per dollar, save on freight costs, too.

As leading producers of barium chemicals for the lube oil industry, we have steadily improved processing methods and continuously raised the quality of our product. Output has been increased so that we can continue to supply the consistently growing demand.

For samples and specifications, contact our nearest office.

fmc CORPORATION ®

MINERAL PRODUCTS DIVISION

161 E. 42nd Street, New York 17

For more data on advertised products, use cards, last page.

At Richfield Refinery, B&W boiler "team" provides

dependable operation with maximum

Two highly efficient B&W boilers of entirely different designs – system engineered into a money saving "team" – are providing operating flexibility and dependability at Richfield's Wilmington, California refinery.

The two boilers are the CO* Boiler, which operates on waste gases from the refinery process, and the PFI, which burns refinery gas, natural gas, or oil with equal ease.

The CO Boiler has been base loaded at 340,000 lbs./hr. full load since its installation in 1954, with an availability exceeding 96%. Developed and pioneered by B&W, the CO Boiler improves refinery economy by burning cat-cracker gas that would otherwise be wasted. The Richfield unit is typical of the many CO Boilers that have solved air pollution problems.

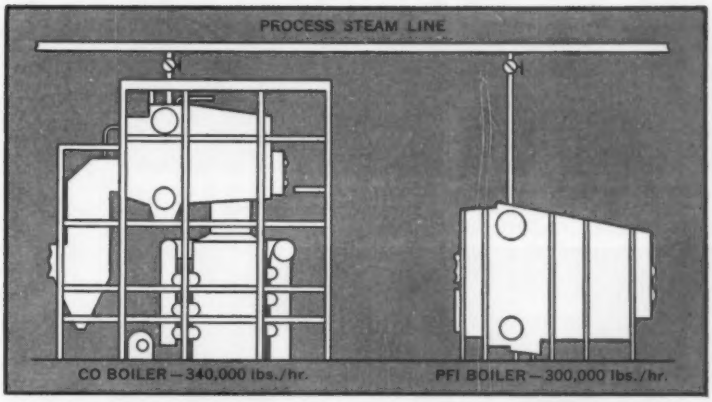
Supplementing the steam produced by the CO Boiler, the PFI boiler is equipped to use the lowest cost auxiliary fuel, whether oil or gas, at all times.

*Reg. U.S. Pat. Off.

MAXIMUM AVAILABILITY — No unscheduled outages have occurred since the CO Boiler (left) and the PFI boiler (right) went on the line. This complete freedom from unscheduled shutdowns plus sustained high efficiency provides Richfield with dependable steam at 640,000 lbs./hr.

PAYS FOR ITSELF—Burning cat-cracker gas that would otherwise go up the stack and pollute the atmosphere, the B&W CO Boiler cuts operating costs to the extent that it, and others like it, pay for themselves in fuel savings in less than 3 years.

FLEXIBILITY OF OPERATION — The PFI boiler helps keep steam generation costs down by providing immediately all needed steam in excess of that which can be obtained by burning the waste gas.



EASY TO OPERATE, INTEGRATED CONTROL CENTER—Fully automated control center equipped with Bailey meters ties this boiler "team" together as a dependable source of low cost steam to meet refinery requirements.

fuel savings

This compact, versatile boiler, designed for 300,000 lbs./hr. supplies steam required in excess of that produced from the waste gases, and responds immediately to changing conditions.

By continually developing more efficient and economical ways to generate steam, B&W has helped many industries to meet growing steam demands at lowest possible cost. For further details, contact The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

G-990-1B

B&W

THE BABCOCK & WILCOX COMPANY

For more data on advertised products, use cards, last page.

THE SURPRISING ECONOMICS OF BONDSTRAND®

...the pipe designed for corrosive chemicals

A 20′ length of 6″ schedule 40 carbon steel pipe weighs 398 lbs. Crane required for lifting.

A 20′ length of 6″ Bondstrand pipe weighs only 60 pounds. One man can lift and carry.

Cutting steel pipe takes four (or more) times longer than Bondstrand.

Bondstrand is cut with ordinary hacksaw. Preheating not required.

Two men required to bevel, clean, position, center and level a 90° elbow before welding.

Only one man required to apply adhesive and position a 90° Bondstrand elbow. It aligns itself.

Welder and helper required to tack weld, check alignment, make stringer weld and grind, make flush weld and grind again, make cover weld, grind and wire brush.

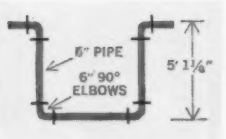
One man with a hammer and a two-by-four makes the Bondstrand Quick-Lock joint in a matter of seconds. Important: **Bondstrand pipe may be handled immediately; no waiting for adhesive to cure.**

IT TOOK 65 MINUTES TO WELD ONE ELBOW TO STEEL PIPE. ONE MAN MADE THE SAME ASSEMBLY WITH BONDSTRAND IN ONLY 10 MINUTES!

BONDSTRAND, the fiber glass reinforced epoxy pipe, handles nearly every corrosive solution—acids, salts, alkalies—used in industry today. It will withstand pressures up to 550 psi and temperatures up to 300°F. So will the complete line of BONDSTRAND fittings, 2″ through 12″.

The smooth, abrasion-resistant inner surface permanently retains its excellent flow characteristics (Hazen-Williams formula C=150) and thus often permits use of one-size-smaller diameter pipe. BONDSTRAND is only one-eighth the weight of steel and because it resists exterior as well as interior corrosion it does not require continual maintenance painting.

BONDSTRAND versatility is unmatched by any other pipe—metallic, thermoplastic, glass or lined. What does this superiority cost? Less than you may suspect. Here is how BONDSTRAND compares with carbon steel in this simple pipe layout:



TOTAL COST OF MATERIAL AND LABOR

Schedule 40 **Carbon Steel** Pipe With Welding Elbows	**$225.63**
Series 4000 **Bondstrand** Pipe With Bondstrand Elbows	**$287.40**

Figures shown are from a strict time-and-cost study conducted by one of Southern California's leading independent piping and engineering firms.

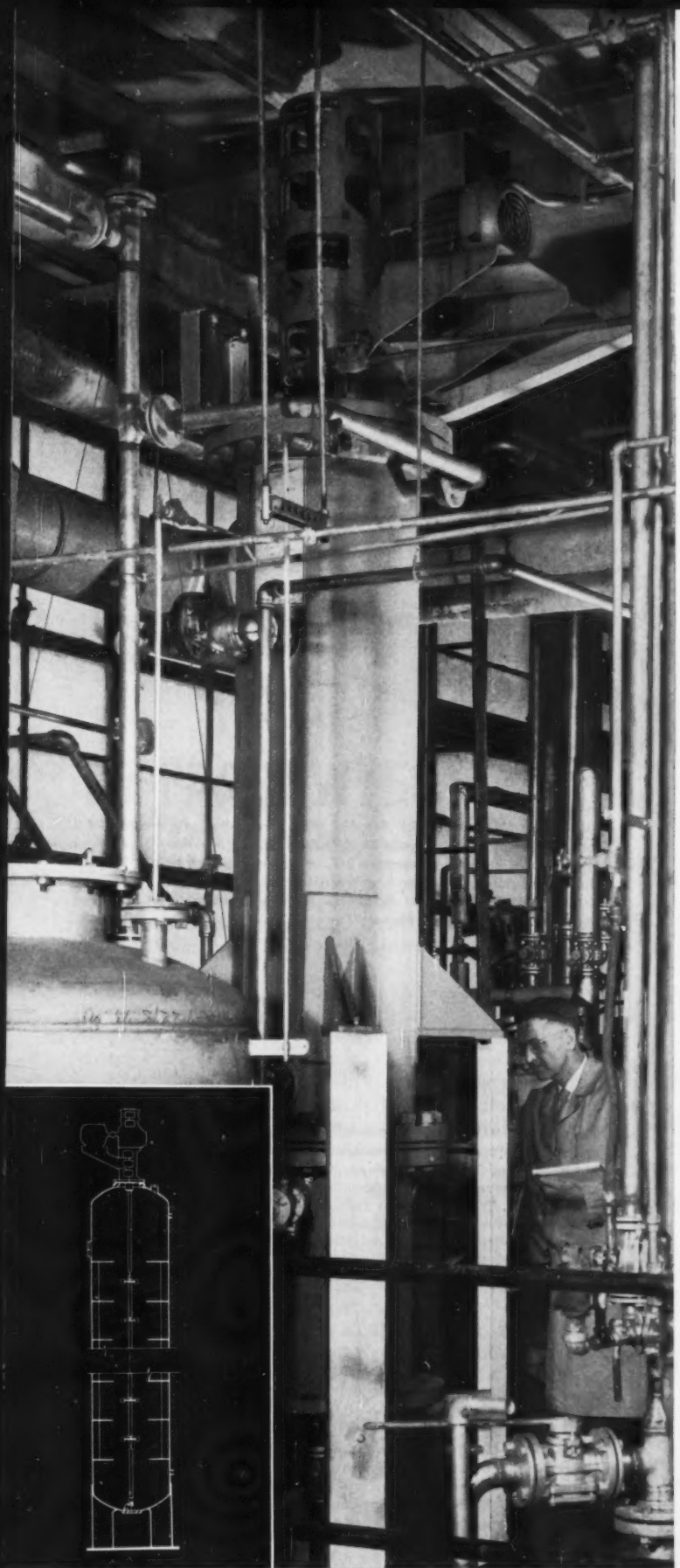
This means that in this layout you get all the advantages of BONDSTRAND for only 21.7% more than ordinary carbon steel pipe. (In complex process piping, BONDSTRAND can actually cost less.) In Schedule 40 stainless steel, which approximates BONDSTRAND's chemical resistance, the layout would cost $1,287.50—*348% more than* BONDSTRAND!

To evaluate the superiority of BONDSTRAND *pipe for your specific requirements, write for complete technical data.*

Amercoat® CORPORATION 136

Dept. V-W, 4809 Firestone Blvd., South Gate, California

921 Pitner Ave. Evanston, Ill.
360 Carnegie Ave. Kenilworth, N. J.
111 Colgate Ave. Buffalo, N. Y.
2404 Dennis St. Jacksonville, Fla.
6530 Supply Row Houston, Tex.



CMCONTACTOR can be pilot plant size or as large and as high as needed. Corrosion-resistant materials are readily supplied. Here a CMContactor reclaims a chemical from process liquor at photo chemicals division of Eastman Kodak Company.

LIGHTNIN CMCONTACTOR®

new multi-stage mixing column handles anything that flows

Don't freeze your plans for "going continuous" on a process until you've had a chance to see what the new LIGHTNIN CMContactor can do for you.

In one package it combines mixer and process vessel, designed to fit your needs, in materials of your choice. It can accommodate *any* fluids, including gas dispersions, heavy slurries, and thick viscous liquids.

It handles any type of continuous operation. And it gives you predictable results.

Here's why you'll find you can get results with the CMContactor that you can't get any other way:

1. **No fouling or plugging.** Simple, self-cleaning design makes it possible to handle fluids of high solids content. Solids can be carried through with the flow stream, settled against the liquid flow current, or retained in the column.
2. **No guessing when you scale up.** Fully baffled system means a controlled flow pattern within each stage, free from problems of channeling, wall effects, packing wettability, and head differentials. Pilot plant conditions can be duplicated with precision in columns of any size.
3. **Selected mixer speed for each flow rate.** As flow rate changes, mixer speed can be adjusted to give optimum performance for that specific throughput.

We help you pilot-plant the process. We'll test-run it for you in our own laboratory. Or you can rent or buy a pilot CMContactor and we'll help you with your own test runs.

To get a fuller idea of the efficiency this versatile new process tool can bring to your operations, call in your LIGHTNIN Mixer representative now. You'll find him listed in Refinery Catalog and in the yellow pages of your telephone book. Or write us direct.

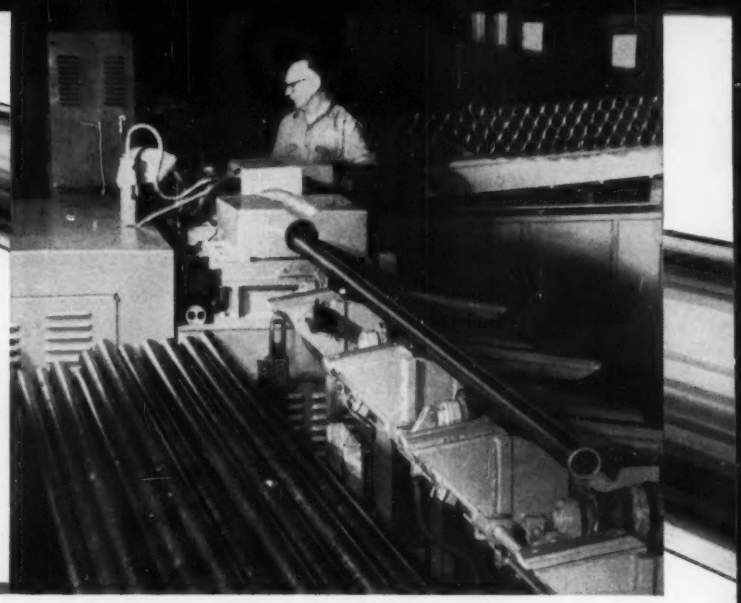
Lightnin® Mixers

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 164-m Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

In Europe: Lightnin Mixers, Ltd., Poynton, Cheshire, England.

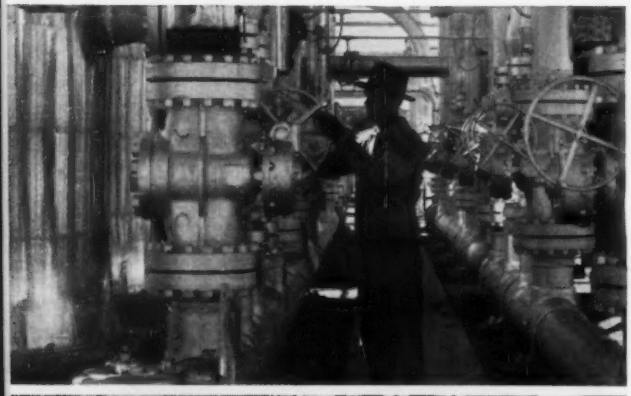


FARROWTEST REJECT TABLE

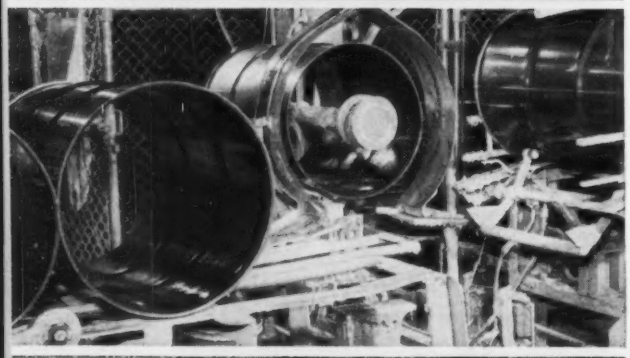
Wall Thickness (B.W. Gage)	Minor dimension of the defect (Length or Depth)	Defective Area (Length, Depth Plane)
20	.006″	.0025 sq. inches
18	.006″	.003 sq. inches
16	12½% of wall	.003 sq. inches
14 and 13	12½% of wall	.004 sq. inches
12 and heavier	12½% of wall	.005 sq. inches

FARROWTEST detects and rejects not only tubing containing defects which completely penetrate the wall; but also tubing with defects equal to, or greater than, those shown in this table. For irregular defect shapes, a tube with defect area equal to or greater than shown above is rejectable. Where required, sensitivity of FARROWTEST equipment can be calibrated to reject defects of lesser specified area than shown in table, at extra cost.

FARROWTEST—QUALITY YOU CAN MEASURE. Not a laboratory theory, not a mere inspection tool, but an exclusive final production test that detects and rejects tubing containing defects of critical size. FARROWTEST is offered as an alternative to other less positive tests in accordance with the table above at no extra cost.



ALLOY STEEL STUDS made by Republic are characterized by accurate, full formed threads. Usually furnished in AISI 4120 Chrome-Moly Steel, heat treated to ASTM A193, designation B-7, or in designations B-14 and B-16 for higher temperatures. Precision heat treatment during manufacture reduces the danger of creep, stretch, or fatigue failure. Send for booklet listing types, sizes, and complete specifications.



ELECTROSTATICALLY LACQUERED DRUMS available from Republic assure peak protection for your product. In Republic's ELECTRO-LAC Process, a fine lacquer mist is dispersed from a high speed distribution head. This mist is uniformly attracted (as a result of an electrostatic field produced in the drum) over the entire interior. Thin spots in the coating are eliminated. Ask your Republic Container salesman for details or mail the coupon.

REPUBLIC SRK® PLASTIC PIPE can save time and money in many oil field jobs. SRK is resistant to crude oil, brine, and sour gas. It costs no more than ordinary pipe, and installation is extremely fast. Available in sizes from ½″ through 8″, SRK is a semi-rigid plastic pipe that can be cut with a handsaw. It is joined with solvent welded plastic fittings and can be installed in combination with existing metal lines. Mail coupon below.

Republic ELECTRUNITE

HEAT EXCHANGER TUBING

by FARROWTEST

as a "FINAL" test after processing

Increasing pressures and more critical applications in the petroleum industry demand that heat exchanger tubing meet highest performance standards—for extended periods of time.

FARROWTESTED Republic ELECTRUNITE Heat Exchanger Tubing assures that these standards will be met and exceeded. FARROWTEST is Republic's exclusive nondestructive eddy-current test.

ELECTRUNITE offers quality you can measure. Every length of FARROWTESTED ELECTRUNITE has been proven by the ultimate in nondestructive production line testing. This is a *final* test, made in accordance with table at upper left, after *all* mill processing has been completed.

Carbon steel heat exchanger tubes are produced to ASTM specifications A-214; stainless tubes to A-249. Both specifications include nondestructive clauses permitting eddy-current testing—FARROWTEST. And Republic offers FARROWTEST as an alternate to other less positive tests at no increase in cost.

Get full information on FARROWTESTED ELECTRUNITE Heat Exchanger Tubing—the tubing in tune with today. Call your Republic representative or write direct.

Strong
Modern
Dependable

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

REPUBLIC STEEL CORPORATION
DEPT. PR-2500-R
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on the following products:

- ☐ FARROWTEST®
- ☐ ELECTRUNITE® Heat Exchanger Tubing
- ☐ Alloy Studs
- ☐ SRK Plastic Pipe
- ☐ ELECTROSTATICALLY Lacquered Drums

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

THIS NEW MEDIUM RANGE CENTER LINE MOUNT PUMP WILL HANDLE VIRTUALLY ANY LIQUID USED IN A PROCESS PLANT

PEERLESS PUMP

Interchangeability feature of Peerless DMR pumps allows tailor made construction from standard parts to fit your plant's exact needs . . .

What's your pumping problem? Are you moving hydrocarbons, process chemicals or perhaps it's corrosive feedstocks that must be transferred. Then the Peerless DMR is the pump for you. Consider these reasons. The DMR will be assembled to handle your exact pumping needs. No need of compromising or re-vamping your intended plans. The DMR is a proven-in-use pump. You get a reliability factor you can be sure of. The integrated features of the DMR reduce need for large stocks of inventory parts—in some cases by as much as 85%. The DMR is an easy pump to apply. Installation is readily accomplished with little downtime. Long operating periods with minimum maintenance attention adds to the savings these pumps offer. And quick accessibility to interior parts simplifies servicing when and if required. What's more, the DMR has an attractive price tag that you will like. So get the full facts now. Write Peerless for a copy of Bulletin B-1610 which describes the new DMR pump in complete detail.

TYPE DMR CHARACTERISTICS

TYPE: Single stage, horizontal, end-suction, top discharge. **DISCHARGE SIZES:** 1", 2", 3" on 8½" frame: 1", 2", 3", 4" on 10½" frame. **CAPACITIES:** Up to 900 gpm. **HEADS:** Up to 450 feet. **WORKING PRESSURE:** Up to 300 psig. **LIQUID TEMPERATURE:** Up to 450°F. **CONSTRUCTION MATERIALS:** Any machinable metal. Cast iron, carbon steel, and stainless steel liquid ends are carried in stock as standard. **DRIVES:** Electric motor or steam turbine. **LUBRICATION:** Oil lubricated bearing frame. **LIQUIDS HANDLED:** Virtually all liquids used in refinery and petrochemical processing.

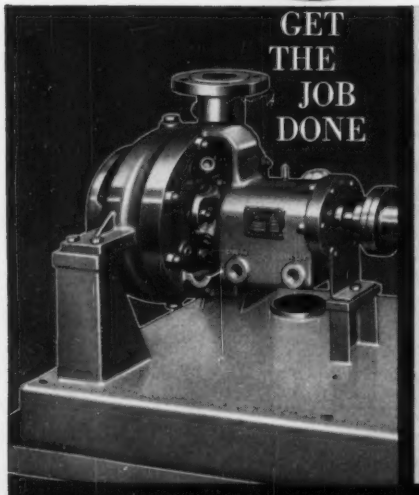
Putting Ideas to Work

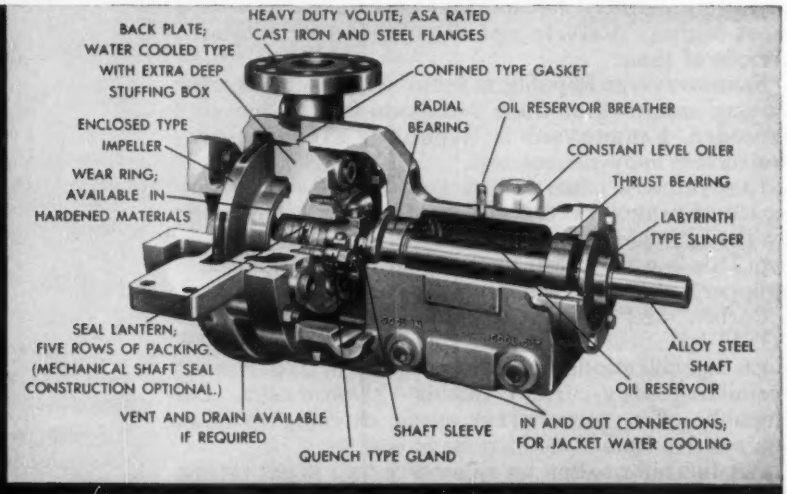
fmc FOOD MACHINERY AND CHEMICAL CORPORATION

PEERLESS PUMP
HYDRODYNAMICS DIVISION
Plants: Los Angeles 31 California, and Indianapolis 8, Indiana.

Offices: New York; Detroit; Chicago; Cleveland; Indianapolis; St. Louis; San Francisco; Atlanta; Plainview; Lubbock; Phoenix; Albuquerque; Los Angeles; Fresno.

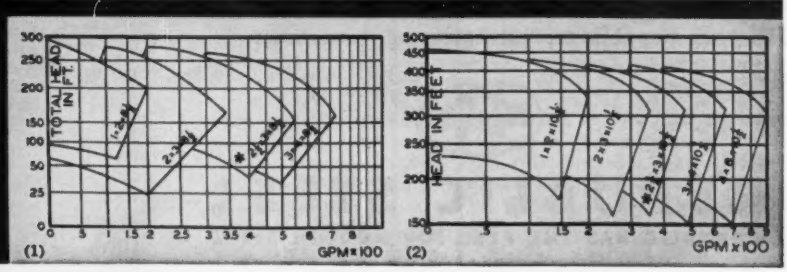
Distributors in principal cities. Consult your telephone directory.




HEAVY DUTY VOLUTE; ASA RATED CAST IRON AND STEEL FLANGES
BACK PLATE; WATER COOLED TYPE WITH EXTRA DEEP STUFFING BOX
CONFINED TYPE GASKET
RADIAL BEARING
OIL RESERVOIR BREATHER
ENCLOSED TYPE IMPELLER
CONSTANT LEVEL OILER
WEAR RING; AVAILABLE IN HARDENED MATERIALS
THRUST BEARING
LABYRINTH TYPE SLINGER
SEAL LANTERN; FIVE ROWS OF PACKING. (MECHANICAL SHAFT SEAL CONSTRUCTION OPTIONAL.)
ALLOY STEEL SHAFT
OIL RESERVOIR
VENT AND DRAIN AVAILABLE IF REQUIRED
SHAFT SLEEVE
IN AND OUT CONNECTIONS; FOR JACKET WATER COOLING
QUENCH TYPE GLAND

PERFORMANCE CURVES
PEERLESS TYPE DMR PUMPS
8½" and 10½" at 3500 rpm

Peerless DMR Pumps are available with both 1750 and 3500 rpm drives. Shown at right are typical curves for (1) 8½"—3500 rpm; (2) 10½"—3500 rpm.



For more data on advertised products, use cards, last page.

NEW

G-R Fin-Fan

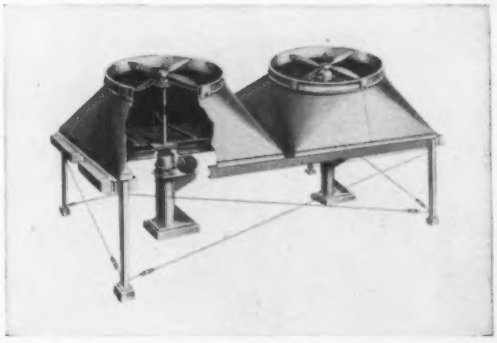
AIR-COOLED HEAT EXCHANGERS

Cutaway View of G-R Forced Draft Fin-Fan Air Cooled Heat Exchanger.

● New design employing four point suspension permits the air moving equipment to be supported on pipe racks or other over-head structures leaving the ground area underneath for use of other equipment.

These air-cooled heat exchangers eliminate the initial, operating and maintenance costs of water pumps, piping, valves and water treatments; and minimize fouling and corrosion problems. They provide efficient, low cost cooling when water is scarce; and are often preferred when water is readily available and inexpensive.

Installations range from single units to those with more than one-quarter billion square feet of heat transfer surface at a single site. Easily installed. Vacuum to 6000 psig, temperatures to 1600°F. Highly endorsed by leading refineries, pipe lines and engineer-contractors.



Cutaway View of G-R Induced Draft Fin-Fan Air Cooled Heat Exchanger.

Get full details! Write for a copy of Bulletin No. 2401 today.

The Griscom-Russell Co.

MASSILLON, OHIO

Affiliated with

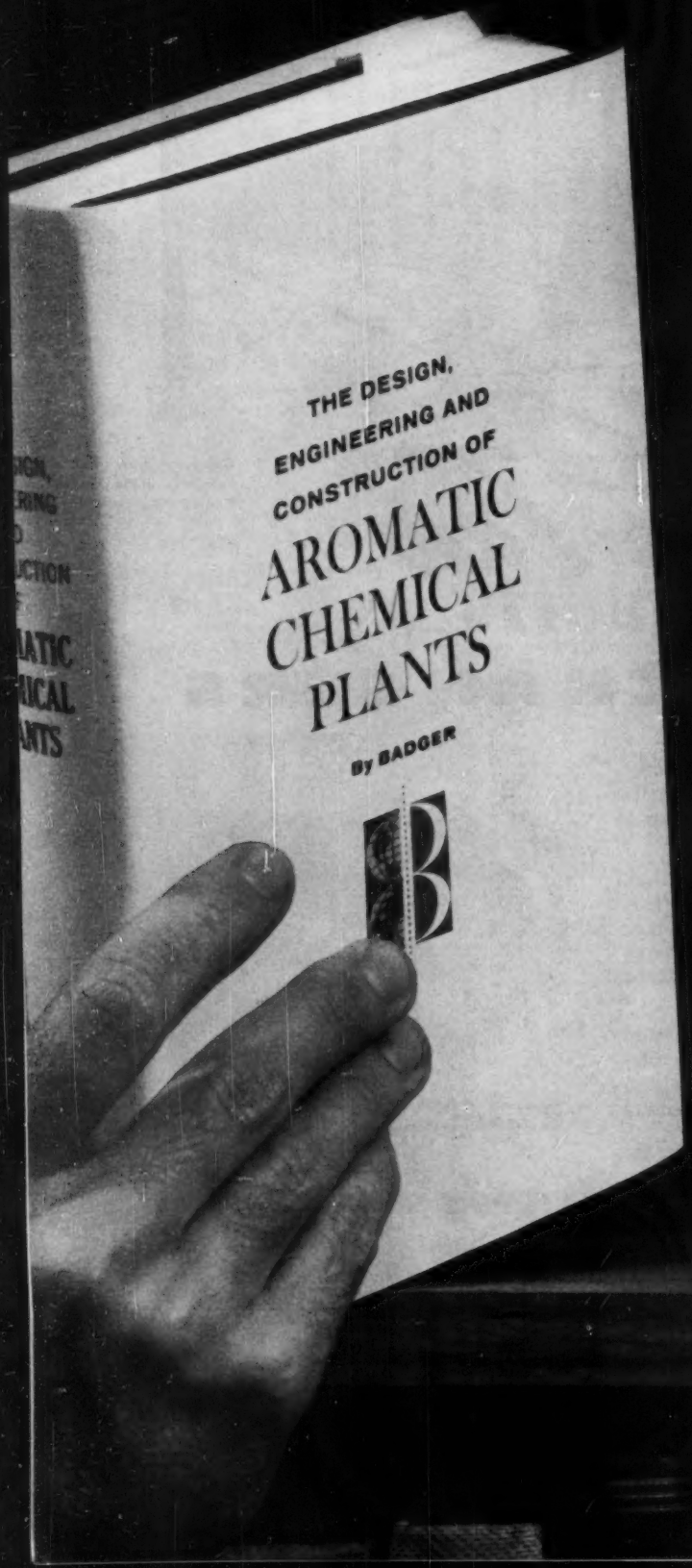
C. H. WHEELER MFG. CO.

PHILADELPHIA 32, PENNA.

Engineering and Sales Representatives in the Principal Cities

KLIPFEL VALVES, INC. • SMART-TURNER MACHINE CO. LTD. *Affiliates*

Shell and Tube Heat Exchangers | Sectional Heat Exchangers | Air Cooled Heat Exchangers | Tank Heaters | Steam Condensers and Ejectors | Single and Multi-Stage Pumps | Marine Auxiliary Equipment



ONLY BADGER COULD WRITE THE AUTHORITATIVE TEXT

Since 1952 Badger has designed, engineered and constructed thirty-eight plants for the production of aromatic chemicals. Their total worth exceeds $70 million; plants range in value from $.3 million to $10 million.

These impressive figures tell only some of the reasons why Badger could "write the book" on aromatics — whether it involves the production of crude products . . . their purification . . . or their conversion into other organic products. Without exception the plants demonstrate the exceptional creativity which is an important part of the stock in trade at Badger. In fact, many of them owe their existence to totally new — in some cases revolutionary — design and engineering ideas. Others, based on more classical engineering concepts, could have been routine plants producing routine products at routine costs. That they are not is again due to the full measure of creativity Badger has brought to their detailed engineering and construction.

When you are considering new facilities for the production of any aromatic, talk first to the people who have made a habit of success in the field. Ask the Badger man for the full story — write, wire or phone today.

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BADGER

INTERNATIONAL DESIGNERS
ENGINEERS · CONSTRUCTORS

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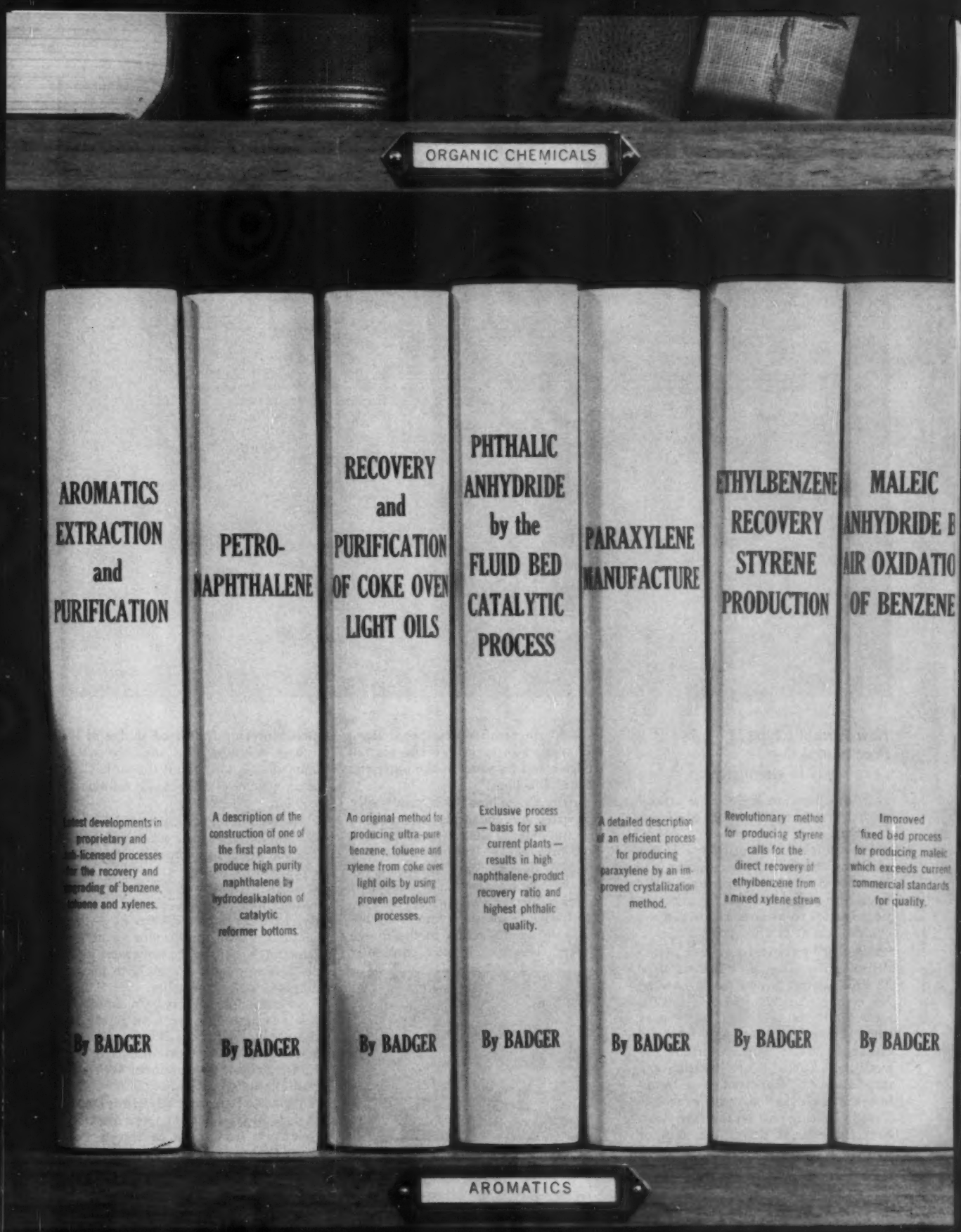
ORGANIC CHEMICALS
AROMATICS EXTRACTION and PURIFICATION
Latest developments in proprietary and ...-licensed processes ... the recovery and ...grading of benzene, ...luene and xylenes.
By BADGER
PETRO-NAPHTHALENE
A description of the construction of one of the first plants to produce high purity naphthalene by hydrodealkalation of catalytic reformer bottoms.
By BADGER
RECOVERY and PURIFICATION OF COKE OVEN LIGHT OILS
An original method for producing ultra-pure benzene, toluene and xylene from coke oven light oils by using proven petroleum processes.
By BADGER
PHTHALIC ANHYDRIDE by the FLUID BED CATALYTIC PROCESS
Exclusive process — basis for six current plants — results in high naphthalene-product recovery ratio and highest phthalic quality.
By BADGER
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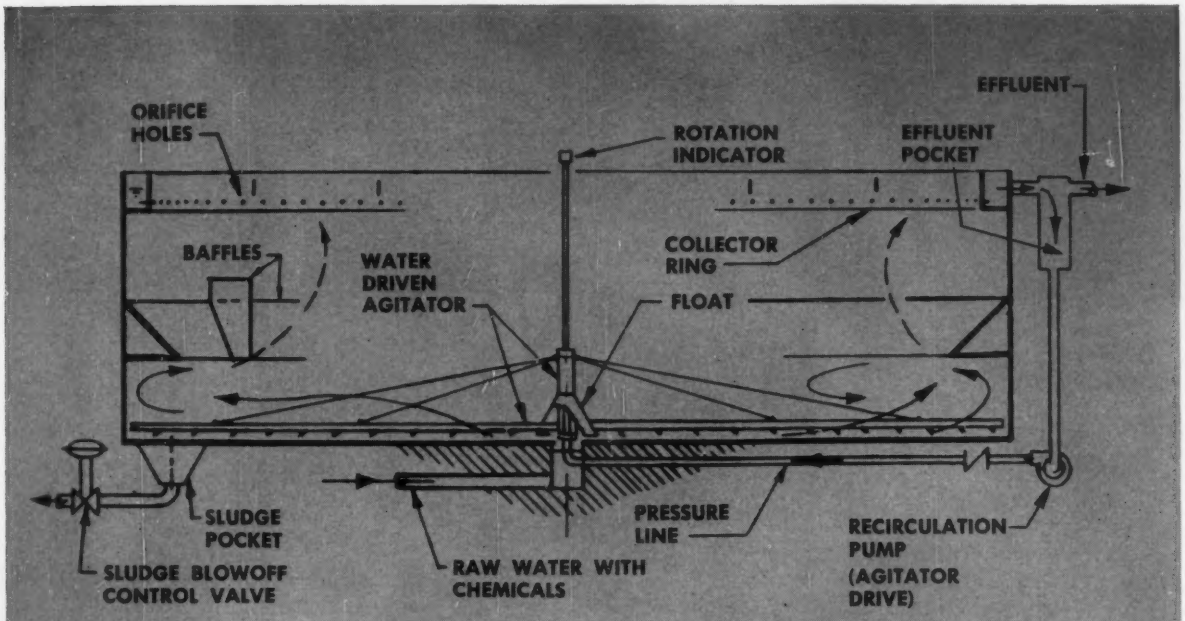
AROMATICS



Will this new precipitator change your thinking about costs, shock loads?

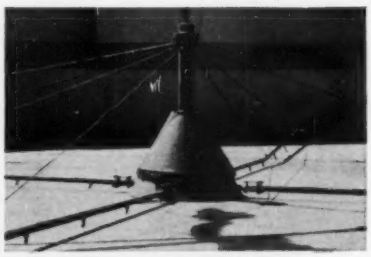
New Permutit Type M Precipitator ... a study in simplicity

Now in operation is this new precipitator for reducing turbidity and color in water.

We call it the Permutit Type M Precipitator. It is a study in simplicity, and because of its low construction and operating costs, it opens up new opportunities to obtain solids-contact clarification at minimum cost.

"Missing" parts: There is no motor-driven agitator on the Permutit Type M Precipitator. No extensive baffling. No center platform. No access walkway. All these have been done away with, because the unit has a new and different agitator system which sweeps away the settled sludge. Rotating agitator arms are supported by a "semi-buoyant" hub (or float) which revolves about a bearing post on the tank floor. Recycled effluent drives the agitator through jet nozzles located at the end of each arm. Smaller jets, spaced along the arms, gently nudge the settled sludge toward a sump at the outer rim of the tank floor.

Briefly, this is how the M unit works: raw water and chemicals are mixed in line and enter at the center of the tank floor beneath the conical rotor float which deflects the fluid mixture radially outward to the walls. A horizontal baffle on the tank wall then reverses the flow back toward the center thus imparting a rolling action to the sludge blanket. This current flow constantly places previously formed sludge in intimate mixture with the raw water immediately as it enters the tank. Clarified, effluent is collected by a flume at the top.



Agitator float and hub assembly.

Sudden water changes: An additional benefit of the Permutit Type M Precipitator is its exceptional ability to handle shock loads.

A case in point: red dye from a paper mill a mile upstream showed up one day in the raw water entering a Permutit Type M Precipitator in use in New England. But the unit went right on putting out an effluent with no significant change in quality.

So much interest has been shown in this new unit that we have reprinted the paper, "A Recent Development in Solids Contact Clarification Design", by E. D. Driscoll of Permutit. We'll be glad to send you a copy.

Write to Permutit Division, Dept. PR-111, 50 West 44th St., New York 36, New York. (In Canada, contact the Permutit Company of Canada, Toronto.)

PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS ... the science of fluid processes

Packed Tower Performance Improved with

"GAS-INJECTION" SUPPORT PLATES

The dramatically lower pressure drops expected through the higher bed voidage obtainable with Intalox® Saddles and Pall Rings cannot be realized when the packing support plate restricts gas and liquid flow.

For maximum performance from these newer packings, the support plate must provide an effective free area equal or greater to the free area of the bed (which in some instances may run as high as 95%).

To meet this need, U. S. Stoneware engineers have developed a series of packing support plates based on the principle of injecting the gas into the bed above the point where the liquid disengages. Thus, liquid leaving the column cannot restrict gas flow into the column and the low pressure drops anticipated from Intalox Saddles and Pall Rings can be fully realized.

"Gas-Injection" Support Plates* are made in a variety of types and from a number of materials.

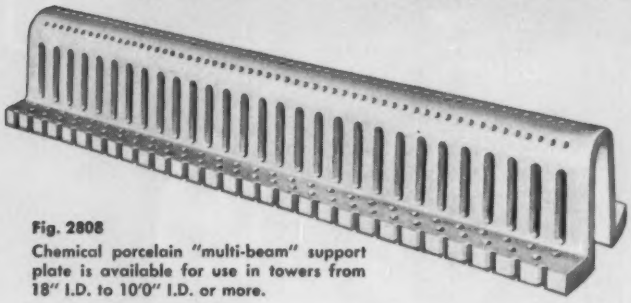


Fig. 2808
Chemical porcelain "multi-beam" support plate is available for use in towers from 18" I.D. to 10'0" I.D. or more.

Fig. 819
Fiberglass re-inforced plastic "multi-beam" support plates are available for towers up to 8' or larger in diameter.

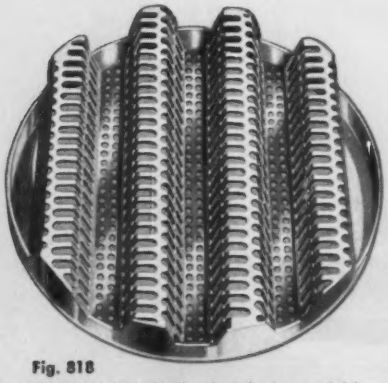


Fig. 818
The "gas-injection" principle is available in any of the weldable alloys or elements in one-piece or two-piece construction for towers 12" through 48" or in multi-beam construction for towers of unlimited size.

(Carbon plate)
Support plates incorporating the "gas-injection" principle are likewise available made from impervious graphite.

*Covered by patents granted or pending.

433-G

WRITE FOR THIS NEW BULLETIN

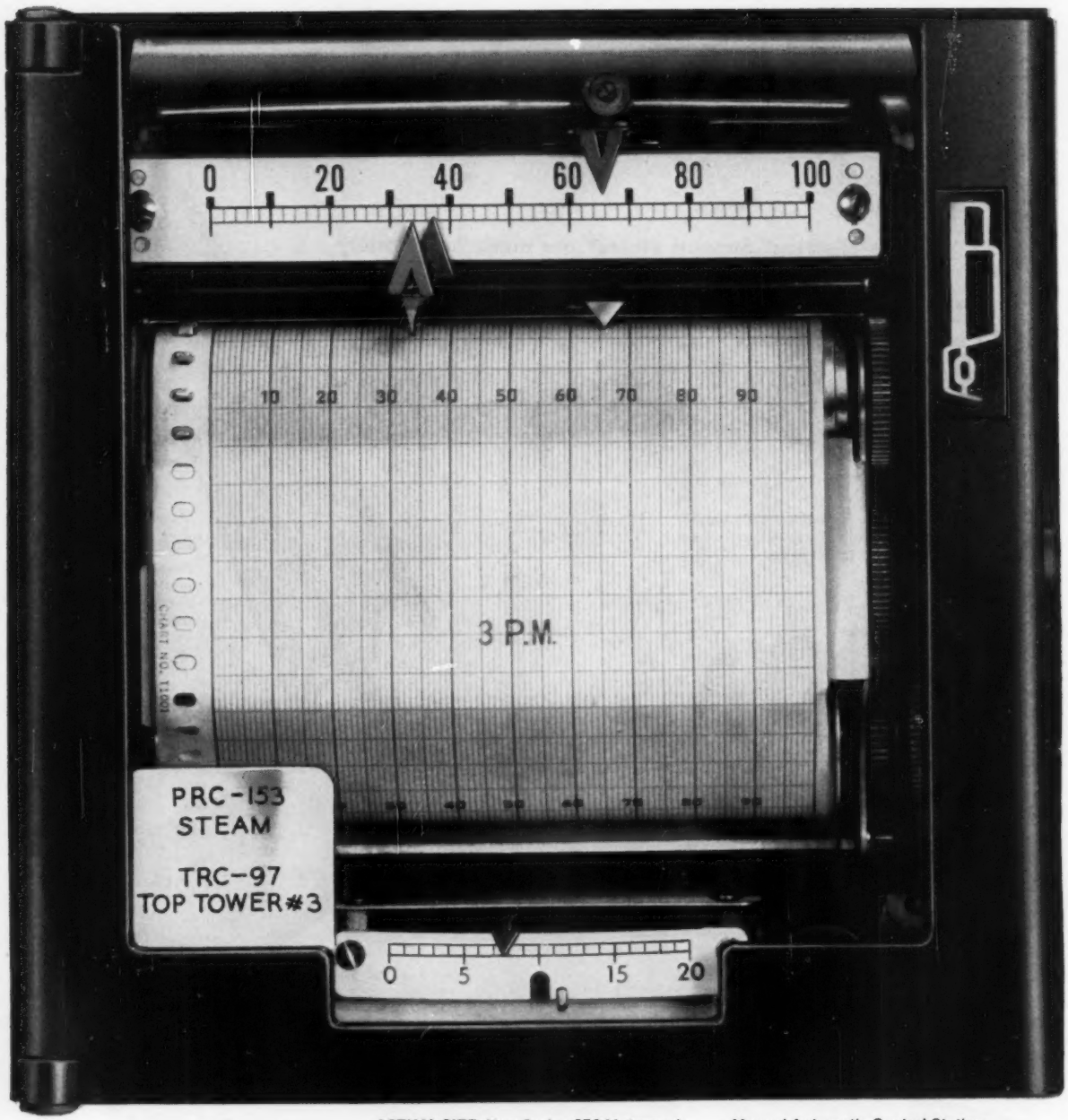
Bulletin TA-40 gives full technical data on "gas-injection" support plates, plus U. S. Stoneware's line of distributors and hold-down plates. Free on request. Write Process Equipment Division.

Process Equipment Division

U. S. STONEWARE

AKRON 9, OHIO

NEW..



ACTUAL SIZE. New Series 670 Metagraphic is ideal for graphic panel applications, occupying panel space only 7" wide by 7⅛" high. Fits into 6" by 6" panel cutout. Typical 670 Series models available, include:

- 1-Pen, 2-Pen, or 3-Pen Receiver
- Manual-Automatic Control Station
- Manual-Cascade Control Station
- Manual-Automatic-Cascade Control Station
- Single-Case Cascade Control Station

here's the pneumatic receiver you asked for!

Bristol's new 4-inch-chart Metagraphic receiver

is the easiest yet to install, operate, and service

Never before has a 3-15 psi pneumatic receiver been designed with such exacting, meticulous attention to the needs of the graphic panel designer, the instrument user, and the instrument maintenance man.

Bristol's new Series 670 Metagraphic receiver brings you the plug-in versatility and operating convenience—made famous in previous Metagraphic pneumatic receivers—plus the increased legibility and accuracy of a 4-inch strip chart, plus these big new features:

Simplified control switching between functions... allows the easiest start-up procedure for either the common manual-automatic station or the more complex, single-case cascade control station models. Intermediate "seal" position has been eliminated. Just adjust process to line-up color-coded indicators and switch to automatic or cascade operation as desired.

Uniform control switching . . . all receiver models have the same switch positions for the various types of control —cascade position, 3 o'clock; manual position, 6 o'clock and automatic position at 9 o'clock.

Simplified chart change and inking . . . chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be refilled from the front of the receiver.

And the new Metagraphic receiver gives you other outstanding features such as rectilinear chart coordinates for easiest reading, easy connections for any type of control, either field or receiver-mounted controllers; and sparkless, mercury-switch disconnect of electrical circuit when chassis is removed.

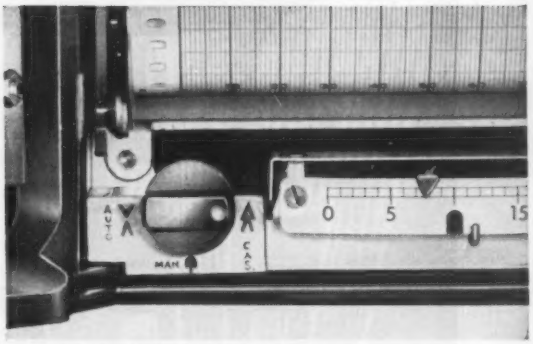
Get the complete story on the new Bristol Metagraphic receiver today. Write The Bristol Company, 111 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.42

ACCO

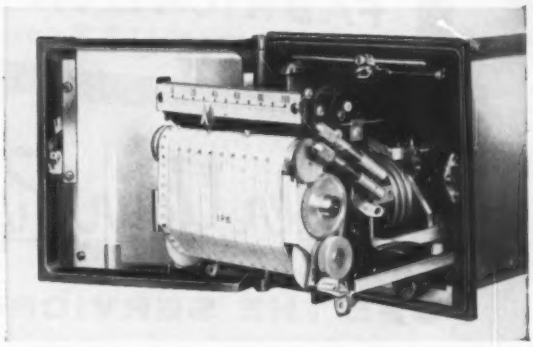
BRISTOL

...for improved production through measurement and control

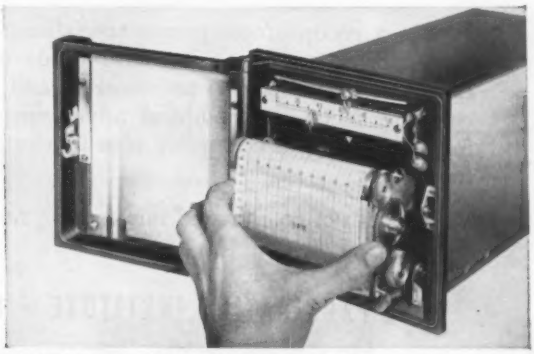
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



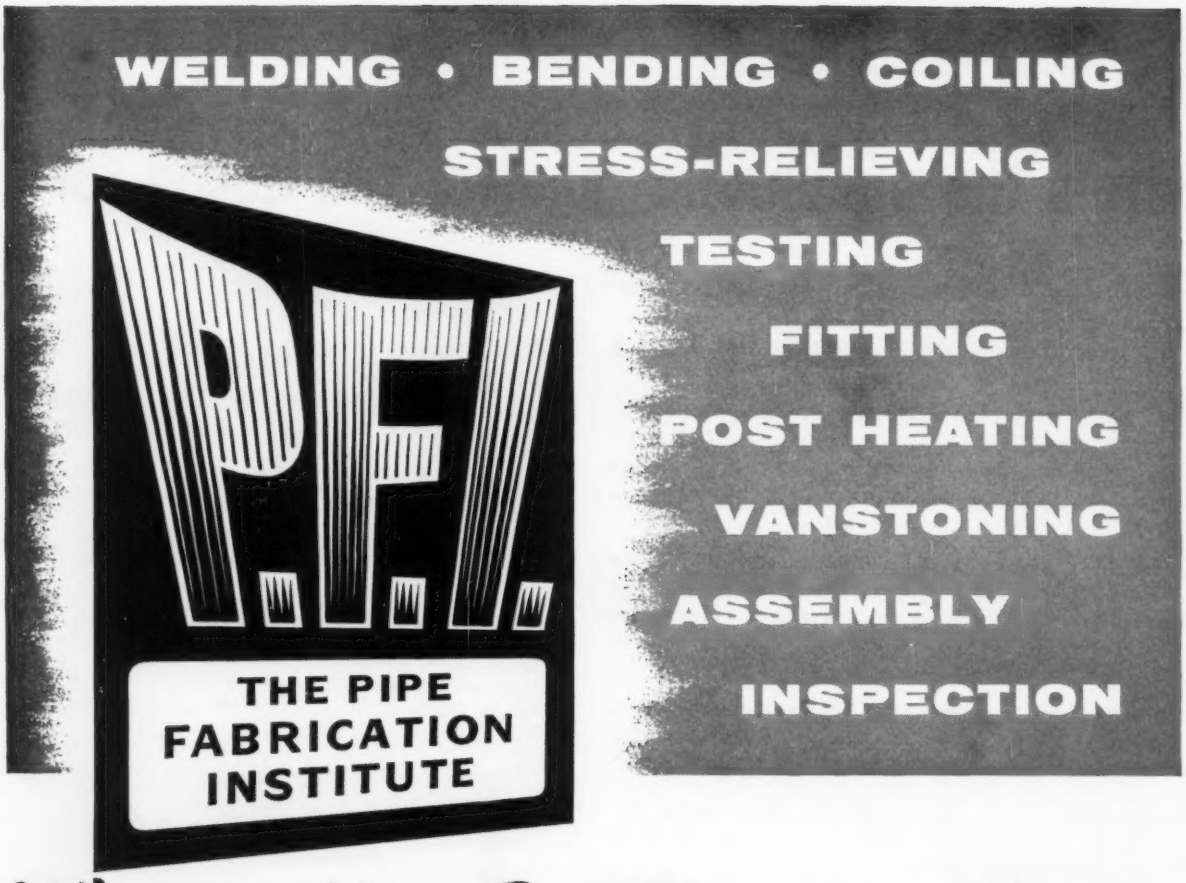
Simplified control switching is keynote of new receiver's design. For instance: uniform switch positions on all models avoid operator confusion in multi-receiver installations; simple alignment of color-coded pointers and a single switching operation put complex automatic or cascaded systems "on stream."



Complete "plug-in" service continuity. Entire plug-in receiver chassis is instantly replaceable with spare for complete continuity of service. Control functions are not disturbed when receiver chassis is removed.



Easiest to service . . . For instance: Easily removable chart drive mechanism—a one-handed operation—permits exceptionally fast chart replacement; just slip out drive, replace with spare, replace paper in original drive at leisure.



Whatever Your Pipe Fabrication Needs

USE THE SERVICES OF A P.F.I. MEMBER

The Pipe Fabrication Institute is *not* just another trade association with industrial relations its prime purpose.

PFI is a group of companies specializing in pipe fabrication who contribute funds and experienced manpower to research and to correlate facts and technical advancements for the purpose of improving pipe fabricating techniques.

This wealth of coordinated information relating to the establishment of high standards for high pressure and high temperature piping has been widely distributed through all industry. PFI publications covering this information are listed below and are free upon request.

So, when you select a piping fabricator, it's to your advantage to specify PFI member companies . . . your confidence will be rewarded by dependable service, engineering assistance and complete satisfaction in meeting exacting specifications.

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1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
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4 Shop Hydrostatic Testing
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6 Built-up Weld, Metal Bosses
7 Welded Nozzles — Spacing
8 Preheat - Postheat Welding, Low Chrome — Moly Pipe
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices
11 Affixing Permanent Symbols to Piping
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PENNSALT SERVICE *helps you get*
PROVED SAVINGS
in HYDROFLUORIC ACID alkylation

Have you looked at all the economic advantages of alkylation with hydrofluoric acid? Pennsalt's pioneering and specialization in AHF can help you realize big savings in your alkylation process: **1** Lower catalyst cost . . . **2** Elimination of spent acid problems . . . **3** Reduced acid inventory . . . **4** Lower cooling expense . . . **5** Shorter reaction time . . . **6** Faster catalyst settling . . . **7** Minimum side reaction products.

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. . . includes engineering data, handling and storage information. Write for Bulletin S-148.

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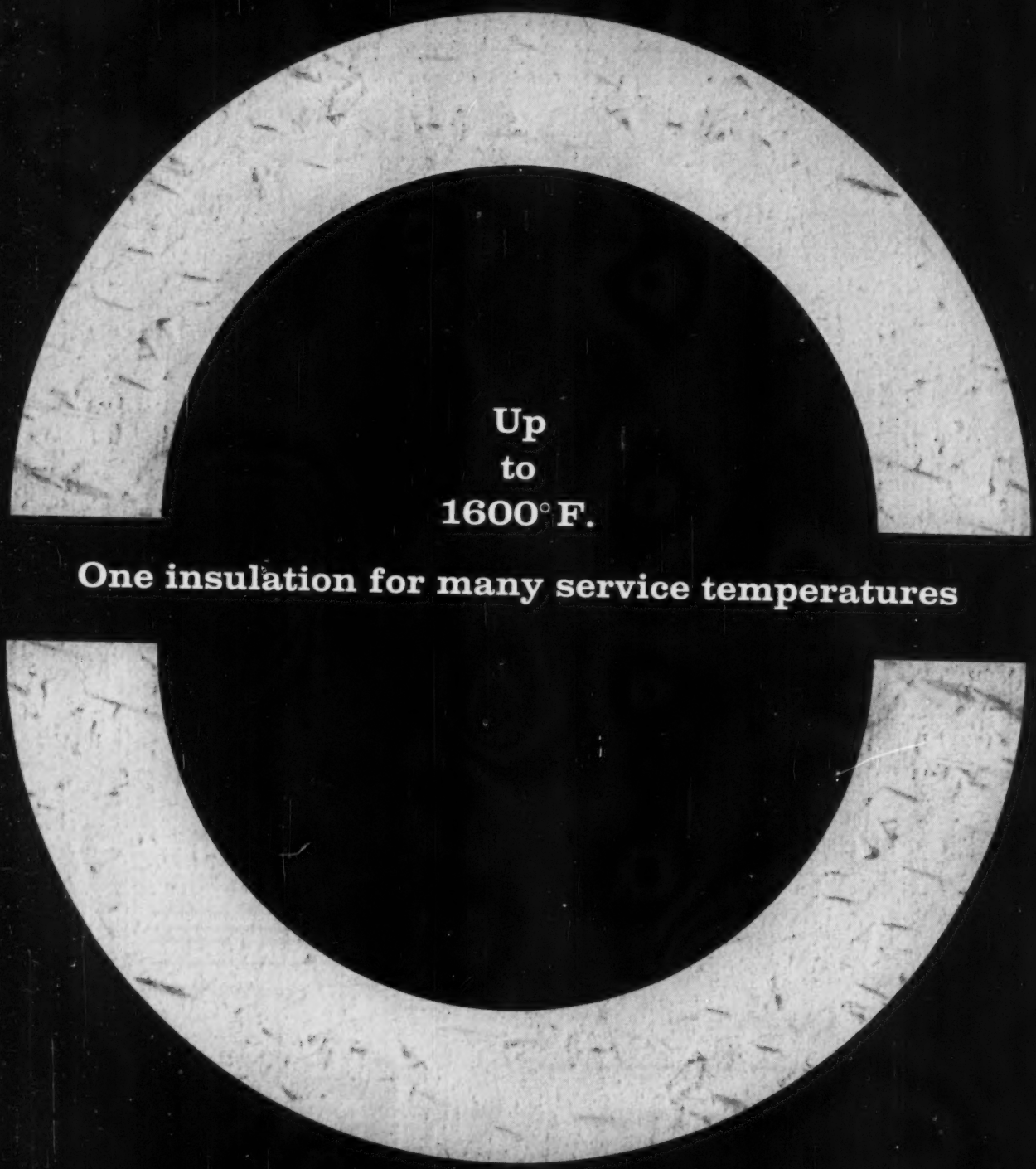

One insulation for many service temperatures

This is **Careytemp**®

Composition
A new pipe and block insulation material . . . millions of glassed-in air cells of expanded silica bound together, reinforced with inorganic fibres. Gives exceptional strength, yet is lighter than other industrial insulations. Density: 9 lbs. per cu. ft.

High Moisture Resistance
Absorbs practically no moisture. Minimum efficiency loss under wet or humid conditions.

Low Shrinkage
Practically no linear shrinkage, even at high temperatures (0.7% at 1200° F.). Minimum heat loss at joints.

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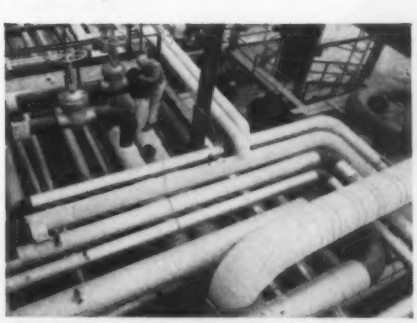
Only .33 B.T.U./sq. ft./hr./°F. at 100° F. — .77 at 1000° F. mean.

High Acid & Corrosion Resistance
Improved performance on acid-processing and stressed stainless steel equipment. Not damaged by most acids. Chemically-inert composition ideal where corrosion is a problem.

Wide Size Range
Available in larger labor-saving sizes. Blocks in new 24″ widths and pipe insulation in half sections through 24″ pipe size.

Over four years of field use have proved Careytemp, following thorough laboratory testing at Mellon Institute of Industrial Research. For Careytemp samples and additional specifications, write Dept. PR-1161, Insulation Division, The Philip Carey Mfg. Company, Cincinnati 15, Ohio.



Sohio Chemical Company, Lima, Ohio. Careytemp specified exclusively to cover the wide range of temperatures encountered in this modern chemical processing plant.

MASONEILAN
ELECTROPNEUMATIC POSITIONER...

Arranges Happy Marriage

Between Electronic Controller and Pneumatic Control Valve

The advantages of the electronic controller can now be mated to the superior power and smooth throttling action of the pneumatic control valve by means of Masoneilan Model 8010 Electropneumatic Positioner — the most advanced device available for converting electric output signal to pneumatic positioner output.

Fidelity of positioning is assured because Model 8010 is a true positioner providing *direct* comparison of valve stem position with controller output signal, resulting in dynamic response and accuracy *not possible with any combination of transducer and positioner.*

Compatibility with any presently available electronic controller is obtainable because design provides for adaptability to all usual controller output signals.

Character of the design results in high open-loop gain and closed-loop stability. Balanced beam permits installation of the valve in any position without calibration shift.

You Are Invited to join the growing number of users who recognize the superior merits of Masoneilan Electropneumatic Positioners. The first step — obtain complete information. Get in touch with any Mason-Neilan office or representative; or write direct to

MASONEILAN

Products that work for your profit

MASON-NEILAN

Division of Worthington Corporation

51 Nahatan Street, Norwood, Massachusetts

DESIGN FEATURES

- Extra large stabilized magnet, plus efficient magnetic circuit, provides high-force changes.
- External stroke adjustment accessible without removal of cover — no exposure of electric wiring.
- High capacity relay for fast stroking speeds. Relay may be mounted in any one of four positions to facilitate piping.
- Balanced beam permits installation of valve in any position without shift in calibration.
- Available for 3-15 psi or 6-30 psi valve spring ranges and for split-ranging. Standard stroke ranges ⅜" – 3" and 2" – 4". Others available.
- Available with direct or reverse action and for direct or reverse actuators.
- Explosion-proof construction meets requirements of Class I, Division I, Group D.

PERFORMANCE DATA

Open-loop Gain* — approx. 100

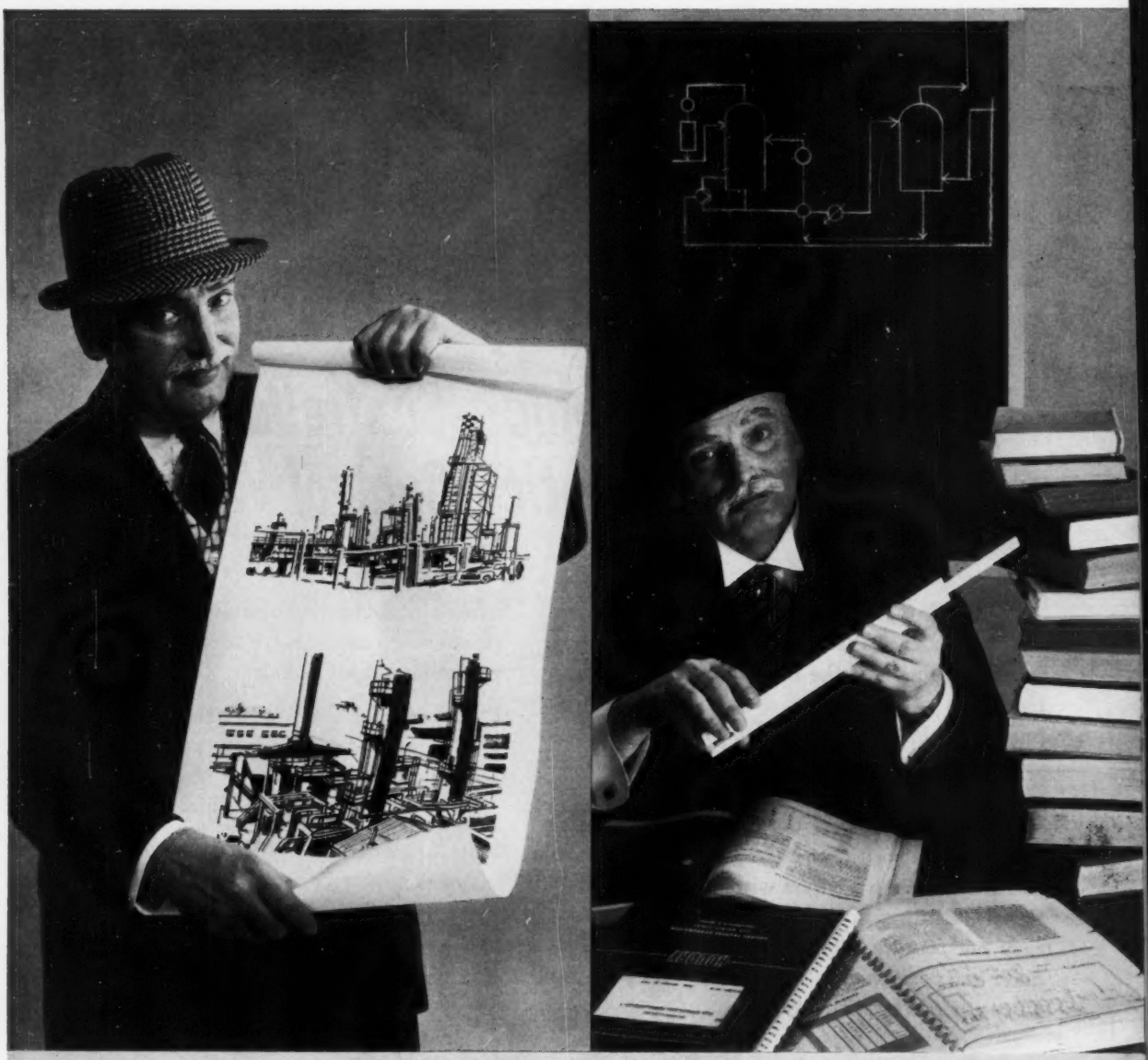
Linearity—within ±1% of full stroke

Repeatability — within 0.2%

Load Sensitivity — output pressure change of 1.2 psi per 0.1% of full stroke offset

Supply Pressure Effect — ±1% of full stroke for ±5 psi change from 20 psi

*Defined as $\frac{\%\text{ of full stroke}}{\%\text{ of full input range}}$



- Design and licensing of catalytic processes for the petroleum refining, petrochemical and chemical industries.
- Economic consultation, engineering, research, and technical assistance in petroleum, petrochemical, and chemical processing.

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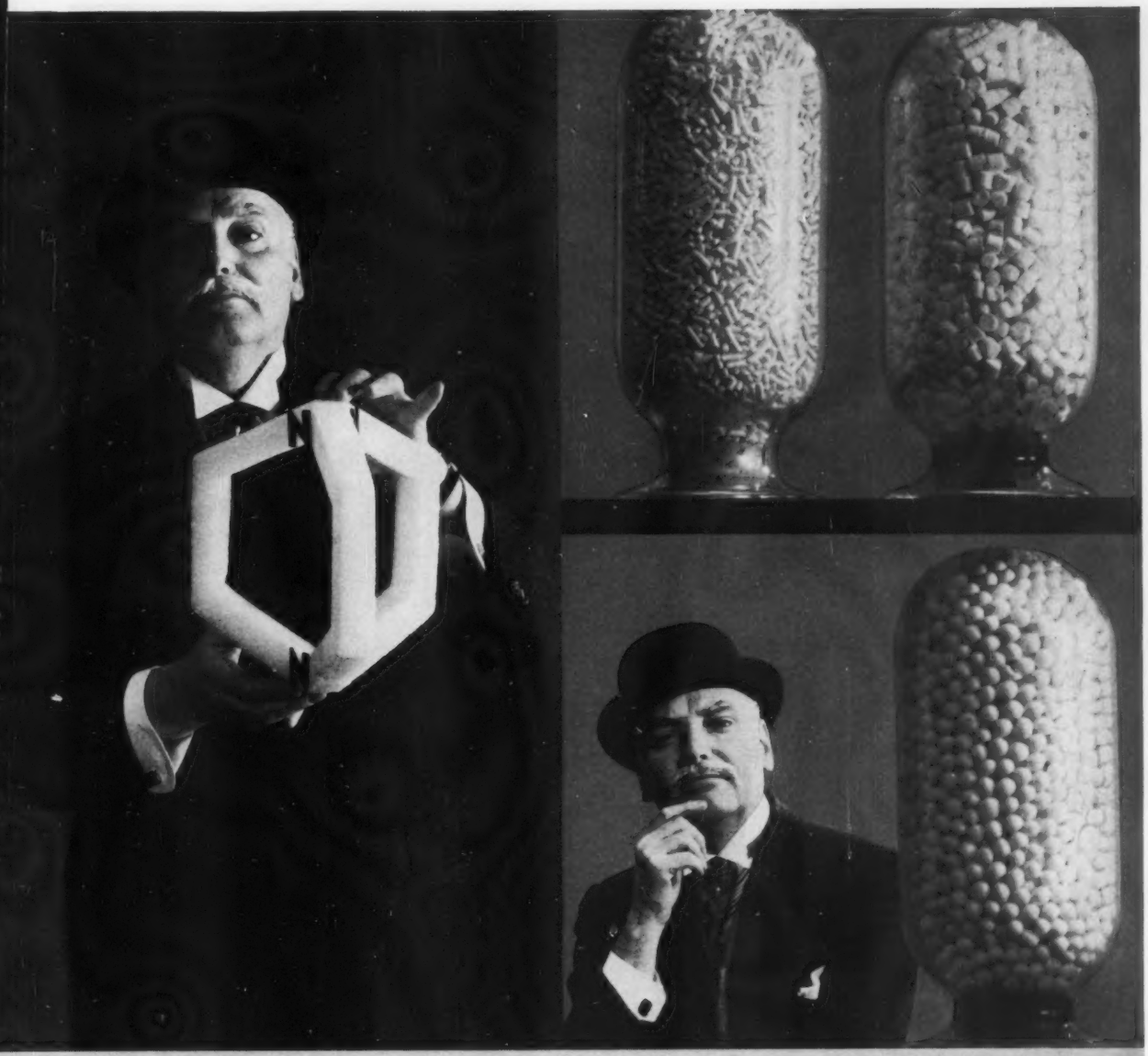

- Newly-developed nitrogen-containing organic chemicals with wide commercial possibilities.
- A broad selection of catalysts for petroleum, petrochemical and chemical processing, including custom catalysts manufactured to order.

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***Houdry means Progress... through Catalysis**

Contracting for Houdry products, or any one of Houdry's processes and services, gives you access to a wealth of basic knowledge gained in 32 years of experience in the field of catalysis. Houdry offers well-proved capability in process design and preparation of catalysts to solve problems in petroleum refining, petrochemical processing, and chemical processing. And by studying and evaluating catalysis in a wide range of commercial situations, Houdry has not only developed processes, products and services, but has recorded information and perfected procedures to help you get full value from them.

For more data on advertised products, use cards, last page.

LARGE MID-WESTERN REFINERY uses well over 200 LimiTorque VALVE CONTROLS

. . . on Platinum Catalyst Reforming Units

The above illustration shows a LimiTorque Motorized Valve Control mounted on a 12", 600 lb. valve on a platinum catalyst reforming unit . . . This is just one installation of well over 200 such units used in this modern, well known refinery, and is but one of many thousands of LimiTorque controls used throughout the refinery field in America and foreign countries.

These LimiTorque units are of explosion-proof design having motors with Underwriters Labels . . . They are also equipped with position indicators which transmit valve position back to the control point.

There is no guesswork or labor connected with the LimiTorque Valve Controls . . . from a conveniently located control point, one key man can open and close any type of valve quickly and dependably in remote or hazardous locations.

LimiTorque may be actuated by any available power source, such as Electricity, Oil, Gas, Water or Air; and is available for Microwave control.

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PRECISION GEARS • INDUSTRIAL GEARS • SPEED REDUCERS • FLUID MIXERS • FLEXIBLE COUPLINGS
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GO-DEVIL... first rig to offer refineries new ideas in maintenance, construction, rigging

Speed and mobility are essential to meet tight schedules during maintenance or expansion of a petroleum plant. Drott's 6,000 lb. capacity hydraulic crane is the first new rig to offer the refinery new methods for maintenance, construction and rigging.

The Go-Devil features a full length side carrydeck (26″ wide) capable of transporting pipes or columns to any length. Total carrydeck capacity is 50 sq. ft. and 8,000 lbs. Low profile of 8′5″ (other models as low as 7′5″) permits you to clear low overhead pipes and get close to maintenance problems. Rear-wheel steer and front-wheel drive combined with a compact 74″ width also gets you in and out of tight spots.

The hydraulic boom telescopes out to 24′ to precisely spot pumps, compressors, valves, gear boxes, pipe. And it rotates in a constant 360°.

Why get a larger more expensive unit when you can trust the versatility of the Drott 60 RM2 Go-Devil with your jobs? Fill out the coupon below now. *Ask about the 45 RF2 and 20 RR2 Go-Devils, too!*

IT REACHES	IT LIFTS	IT SWINGS	IT TRAVELS	IT HAULS
24′ up . . . 16′ out	6000 lbs. with safety	360° continuous rotation	up to 19 MPH	on 50 sq. ft. of deck area

DROTT
MANUFACTURING CORP.
Milwaukee 15, Wisconsin

CLIP AND MAIL TO

DROTT MANUFACTURING CORP.
Materials Handling Division
3126 S. 27th Street • Milwaukee 15, Wisconsin

I'd like more information on the 60 RM2 Go-Devil.
Please rush bulletin MH603.

Name.....

Title.....

Company Name.....

Company Address.....

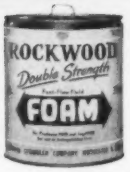
City.....Zone.....State.....

For more data on advertised products, use cards, last page.

The moment they get there...

They put out fires faster!

Rockwood FOAM liquid provides a smothering, fine-bubble blanket over flammable liquid fires. Rockwood's FW Eductor introduces FOAM liquid into water streams.



You get faster extinguishing action when refinery and chemical fire trucks are equipped with Rockwood FOAM apparatus

Once a Rockwood-equipped truck reaches the fire, its FOAM system starts working — enabling fire fighters to hit harder and finish faster.

That goes for all the trucks shown here — just a few of the large number that carry FOAM equipment, developed by Rockwood for specialized fire fighting service at refineries and chemical plants throughout the country.

To these industries Rockwood offers the most complete line of specially engineered systems, devices and accessories for FOAM fire trucks — as well as FOAM systems for protecting refinery and chemical tanks.

Rockwood makes the world's most complete line of specialty turret nozzles. Providing the power so vitally needed at flammable liquid fires, these nozzles can deliver up to 10,000 GPM of expanded FOAM. All are adjustable for handling a solid FOAM stream, FogFOAM, WaterFOG or solid water stream. For details on the many Rockwood products that have proved their exceptional ability in refinery and chemical fires send for illustrated booklet. Rockwood Sprinkler Company, Portable Fire Protection Department, 505 Harlow St., Worcester 5, Massachusetts. Distributors in all principal cities. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company. *Rockwood engineers water . . . to cut fire losses.*

ROCKWOOD

PORTABLE FIREFIGHTING EQUIPMENT

Wolverine TRUFIN® and STEEL ...go together—naturally!

In many applications—design and operating engineers are finding that they can cash in on money-saving benefits by specifying Wolverine Trufin Type S/T (19 fins per inch) in seamless steel.

Trufin—in steel—possesses all of the inherent advantages of integral finned tube. For example:

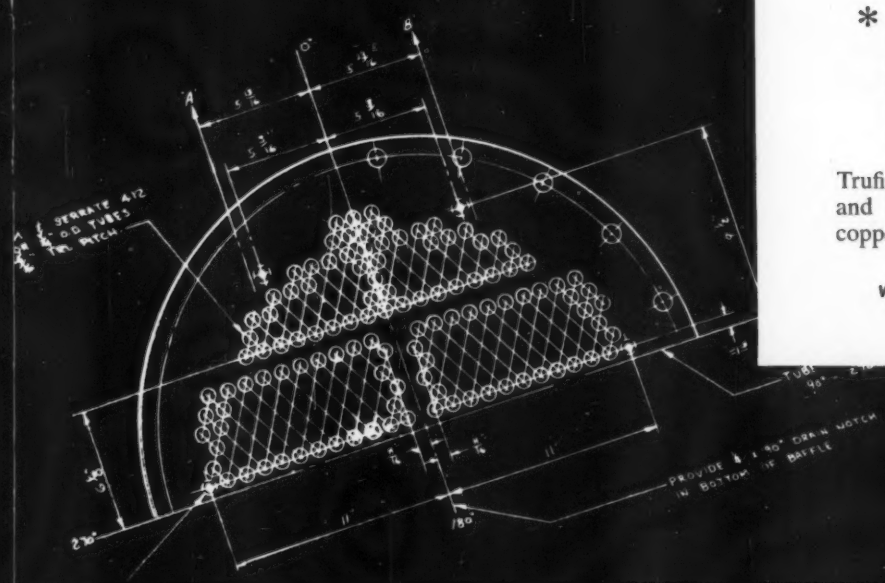
* **In new installations**—Trufin lets you design smaller exchangers without sacrificing capacity. You save on shells, headers, baffles, supports, etc.

* **When retubing**—Trufin's extended surface makes it possible to dramatically increase the capacity of existing exchangers. Trufin Type S/T can be substituted directly for bare tube.

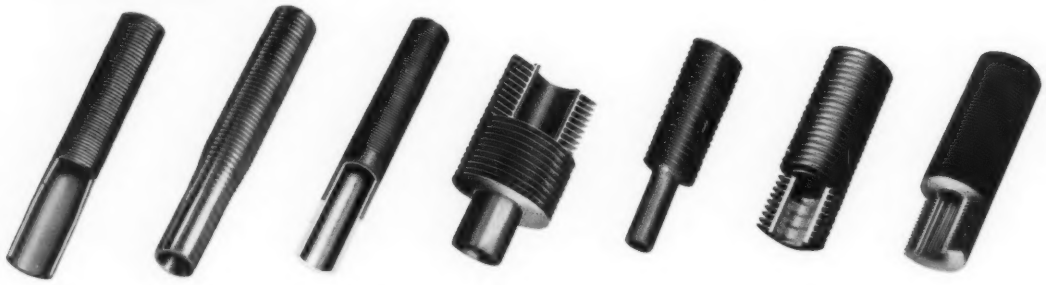
* **Trufin has stamina**—Trufin, because of its integral fins, has the ability to stand up under rigorous operating conditions. Fins are part of the tube wall and are unaffected by temperature and pressure changes and vibrations.

Trufin is produced in many types, sizes, and fin spacings-and in steel, copper, copper alloys and aluminum.

WRITE TODAY FOR MORE INFORMATION.



Look to Wolverine for the complete line of finned tube

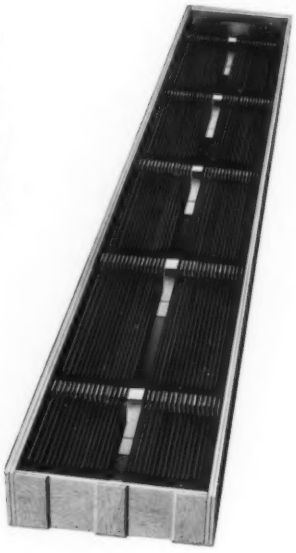


Trufin Type S/T | Trufin Type W/H | Trufin Type S/T (Duplex) | Trufin Type L/C (Bimetal) | Trufin Type H/R | Trufin Type H/A | Trufin Type I/L

Only Wolverine Tube Division of Calumet & Hecla, Inc. can supply you with such a complete line of integrally finned tube – seven different types designed to bring increased efficiency to a wide variety of heat transfer applications. Each type is available in a complete range of sizes and alloys. Ask your Wolverine salesman for information about how these outstanding tubes can help you.

WOLVERINE ALSO OFFERS SPECIAL SERVICES AND SPECIAL PRODUCTS

Wolverine's Field Engineering Service is staffed with specialists trained in tubing selection, alloys, metallurgy, equipment design, etc. Also available for consultation are Wolverine's Heat Transfer Specialists who are located throughout the major processing areas. The services of all these men are yours —without obligation.

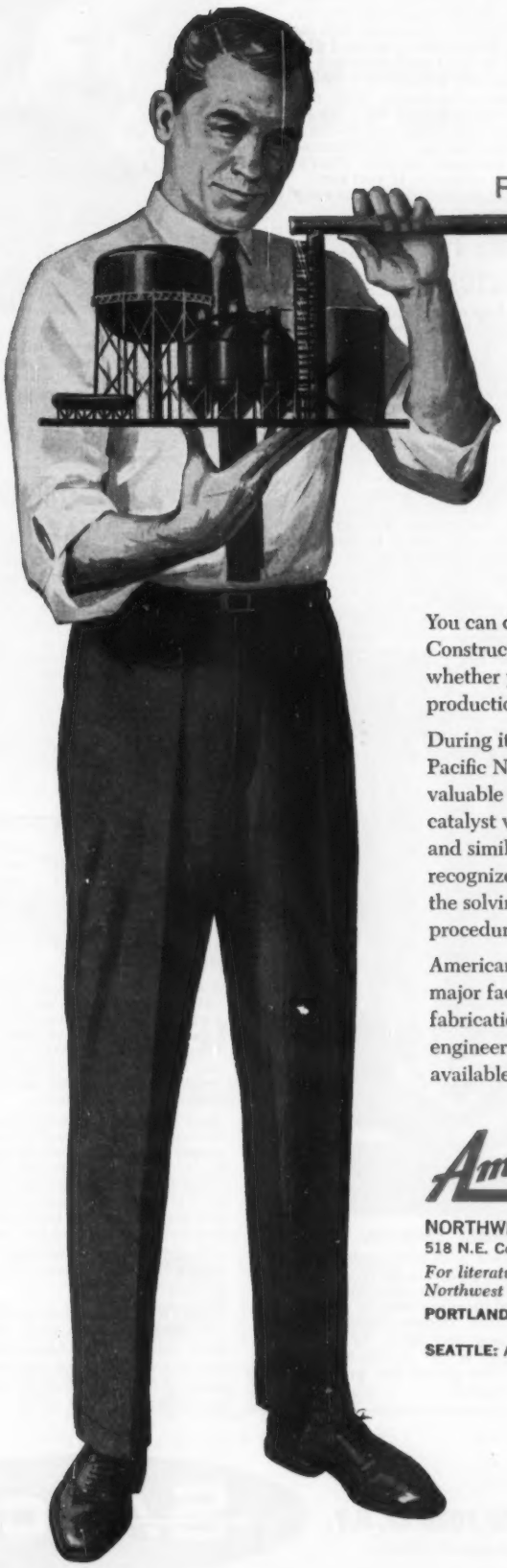


. . . AND, OF COURSE, WOLVERINE TUBE also manufactures a complete line of copper, copper alloy and aluminum prime surface condenser tube. Ask your Wolverine sales representative about Wolverine's complete line of products and services.

Wolverine Tube is also a prime mill source for palletized U-bend condenser tubes—manufactures them to your "specs" and ships them to you in disposable box-type pallets so that you can feed directly from pallet to condenser.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. S, 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
TUBEMANSHIP in Copper—Copper Alloys—Aluminum—Special Metals

PLANTS IN DETROIT AND INKSTER, MICHIGAN AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.



PRECISELY THE FACILITIES YOU NEED!

You can depend on American Pipe and Construction Co. to fulfill your requirements whether you need a single unit or an entire production facility.

During its forty years of service to the Pacific Northwest, American has established valuable experience in the construction of catalyst vessels, distillation columns, storage tanks and similar steel plate fabrication that is recognized in the area. This experience has made the solving of particular problems standard procedure for its engineering department.

American's experience and facilities can be a major factor in assuring you exactly the fabrication you need. Contact an American sales engineer for full information on services available to you in the Northwest.

American PIPE AND CONSTRUCTION CO.

NORTHWEST DIVISION
518 N.E. Columbia Boulevard • Portland, Oregon

For literature or service in the Northwest write or call:

PORTLAND: P.O. Box 1898, Piedmont Station, Portland 11, Oregon; BUtler 5-2531

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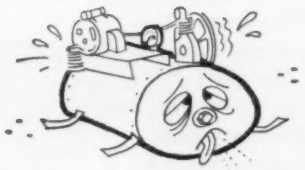
ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

PREVENTION OF CRUELTY TO OLD COMPRESSORS

You've got at least one air compressor, of course. Doesn't everybody? And there it sits, pumping its heart out for you year in and year out. And you there, Simon Legree, do you ever give it a break and measure its capacity?

One measure is the useful work done by your compressed air tools, of course. However, this yard stick may make your compressor installation seem way oversize, but don't blame the equipment. The puffing oldster isn't responsible for choked intake filters, poorly designed suction pipes,



overcooling, undercooling, inadequate distribution mains and wet air. All these things can cost you.

Off and on we're going to talk about compressors in these pages, if you don't mind. It's a big subject and the lesson for today will be confined to the air intake. Can you imagine a more logical place to start?

Where to locate the intake? Easy. Where the atmosphere is clean and cool and dry. Dirty air and grit choke filters and eventually get through to cause wear. The cooler the air, the more you can compress per revolution. You'll get 10% more air delivered at 40°F. than at 90°F. And dryness is imperative, because compressed air can't contain all the moisture it can hold in its uncompressed state. Where does the moisture go? Into mains, tools, and valves, unless it's removed. And need we add that chemical fumes cause corrosion? That includes exhaust gases from engines and furnaces. CO_2 in the presence of oxygen and moisture can rust your valves, tools, nozzles and sprays.

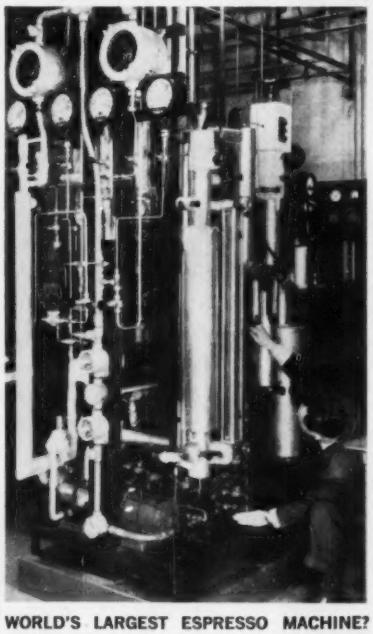
How about intake size? Keep pipes short, sized right, and straight as possible. Small pipes with snaky bends reduce pressure and capacity. For an educated example, a pressure loss due to friction in the intake pipe and filter of 2 psi (14.7 to 12.7) will reduce output of a 125 psi compressor by 7.5%.

How do we know so much? Well, as we continue in future issues, we'll be talking drains and traps and cooling and safety controls for compressors—all of which we manufacture. That's how we know so much. If you can't bear to wait, just write. It's that easy to get information out of us.

SARCO AND THE FLYING DUTCHMAN

In the pipe shop of a major office building complex on New York's east side, the Flying Dutchman flies again. This is really a bright idea which could well become standard practice elsewhere, because it's the kind of logical precaution that would make sense anywhere.

The chap in our photograph is putting together, according to precise, dimensioned drawings, an assembly consisting of a Sarco Thermo-Dynamic Steam Trap, Type TD-50, a Sarco strainer, and valves and fittings for stock. The assemblies will be used for quick and easy replacement in the event of failure or any possible maintenance requirement in the steam distribution system, the heating system, or the air conditioning system.



WORLD'S LARGEST ESPRESSO MACHINE?
No indeedy. It's a pilot plant Hydrofiner unit built by The Lummus Company at its Engineering Development Center in Newark, New Jersey. And its presence here is due to the fifteen ⅜" Sarco Thermo-Dynamic Steam Traps which vent and drain its 35 pound tracer lines plus a ½" TD-50 as a main drip. Nice to be picked for projects like this. Makes us proud.

We'd like to be able to report that this plan recently saved thousands of people from freezing or roasting during a crisis. So far, however, the assemblies have proved to be an ornamental kind of insurance policy. Alas, there have been no failures. That dog-goned Sarco performance is just too reliable for its own good.

WE'VE GOT THINGS TO GIVE AWAY

First of all, we have a new spring clip to hold together a bunch of papers on your desk, or something. It's not complicated, but it *is* difficult to describe, so we've gone to the tremendous expense of having our local Michaelangelo sketch it here. If you have no papers to hold together, it makes a rather delightful snapping noise that might amuse you. Oh yes—it also has a cross section of a TD-50 steam trap printed on it which actually *moves* when you wiggle your eyeballs at it. In case you *still* don't know how a TD-50 works, this is for you.

Second, we've still got engineers' sketch pads which we enjoy giving away so much we're offering them again. In case you're new here (Hello!) they contain isometric grid paper for use by anyone involved in piping or hookup sketches for process or heating applications.

And the famous Sarco key chain, which is really exactly that—a chain—about 60 times as handy as a fat case, we're offering again too. This has a TD-50 replica attached, but detachable. Call it tawdry promotion if you will, but our super-aesthetic wife wears one proudly around her neck.

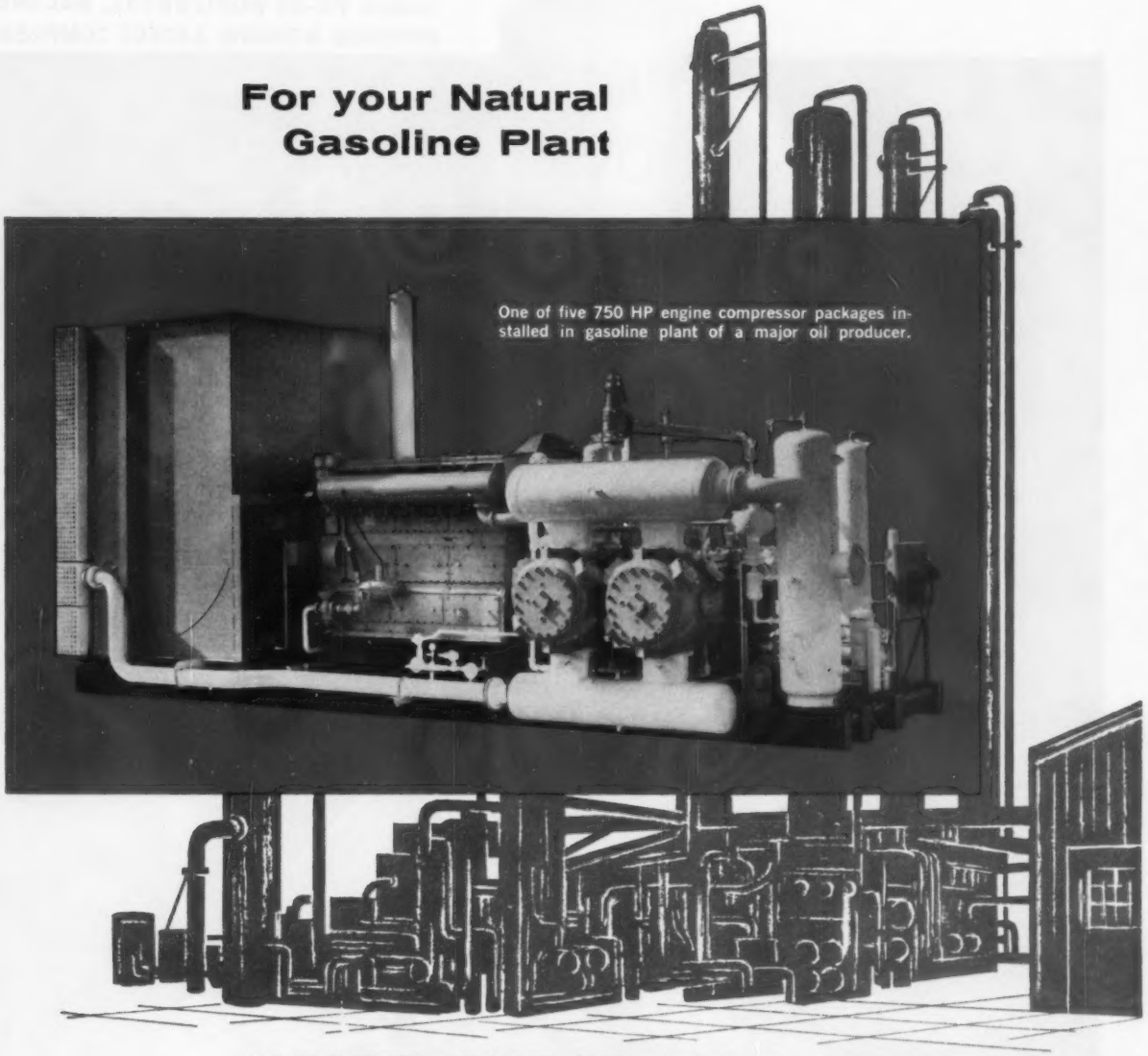
All of these are available from your Sarco representative. Or, if he's out, write in.

There's really no reason to keep this conversation one-sided. After all, we're both interested in these subjects or you wouldn't have read this far. So write, even if it's only about a difficult problem. 7826

SARCO COMPANY, INC., 635 MADISON AVE., NEW YORK 22, N.Y.
STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

SARCO

For your Natural Gasoline Plant



WHITE/SUPERIOR medium speed ENGINE-COMPRESSOR SETS

200-1000 BHP compressors are available for propane refrigeration and allied gas services such as compression of rich oil flash vapors, de-ethanizer overhead gas, etc. Typical is a 6-cylinder compressor utilizing 4 cylinders for 2-stage propane refrigeration and one cylinder each for the other services named above. Combinations range from 2-cylinder 200 HP units for small plants to multiple 1000 HP units for large plants.

Dependable, low-cost White/Superior compressors are designed for exact match with Superior *medium speed* gas engines. The 6″ stroke balanced-opposed compressors direct-coupled to 9″ and 10½″ stroke engines provide optimum combinations of piston speed, horsepower and service life. Two, four and six-cylinder models are available completely packaged; block mounted or skidded; gas, diesel, dual fuel engines or electric motor drives. For engineering assistance pertaining to your specific application or additional data on existing installations, contact your nearby White representative or write to White Diesel Engine Division, Springfield, Ohio.

White DIESEL | Superior ENGINES

White Diesel
ENGINES / COMPRESSORS

CLASS FE-33 HORIZONTAL, BALANCED-OPPOSED, 3-THROW, 3-STAGE COMPRESSOR.

whatever your process requirements

CP COMPRESSOR

exactly right for your needs

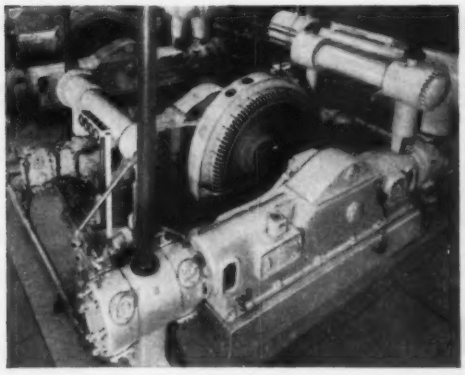
The Class FE horizontal, balanced-opposed compressor is built in a wide range of combinations of crankthrows, cylinder arrangements and stages for pressures up to 15,000 psig; sizes up to 5,000 hp. One such combination is shown at the left.

Other CP Compressors from 7½ hp belt-driven vertical single-acting to 2,000 hp horizontal double-acting with belt, steam or direct motor drive.

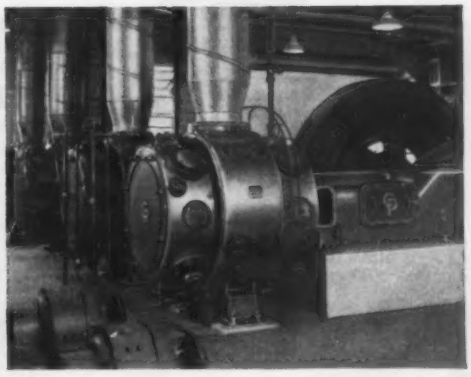
Chicago Pneumatic *8 East 44th Street, New York 17, N. Y.*

Air and Gas Compressors • Vacuum Pumps • Pneumatic Tools • Electric Tools • Diesel Engines • Rock Drills • Hydraulic Tools

Class H, horizontal duplex four-corner, 4-stage.



Class 0-DE, horizontal duplex, double-acting single-stage.

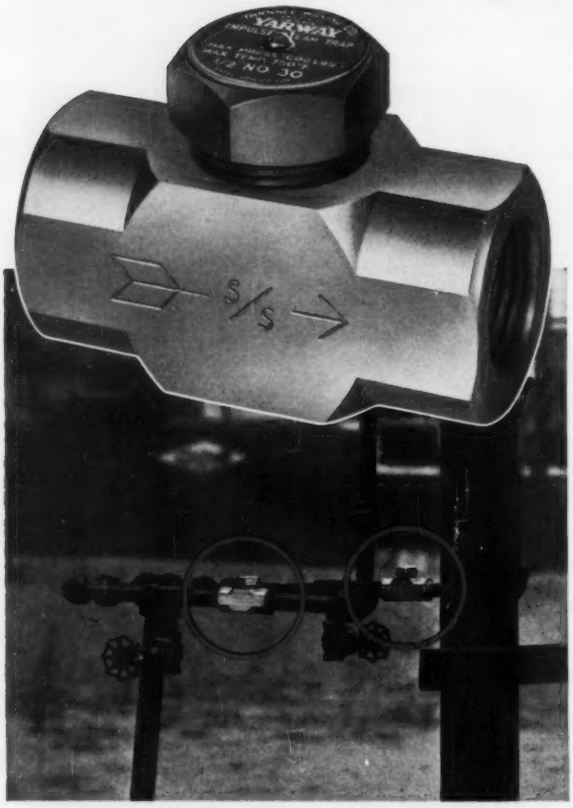


YARWAY news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD
STEAM TRAPS STOCKED AND SOLD BY 270 LOCAL INDUSTRIAL DISTRIBUTORS

YARWAY SERIES 30 IS THE STEAM TRAP FOR PEAK EFFICIENCY



Two Yarway Series 30 traps on tracer lines from a loading station to polystyrene storage tank at the Midland Division of The Dow Chemical Co., Midland, Mich. Steam pressure is 150 pounds.

on tracer lines, main drips, meter boxes and other steam equipment

Yarway Series 30 Impulse Steam Trap has won enthusiastic acceptance and scored outstanding success on those hundreds of applications where condensate is handled in moderate amounts. Here's why:

- Economy of operation, with closer condensate control
- Longer service life, with lever action reducing impact on valve seat
- Lower maintenance, with easily and quickly replaceable seat and disc
- High quality, all stainless steel—combined with a new low cost

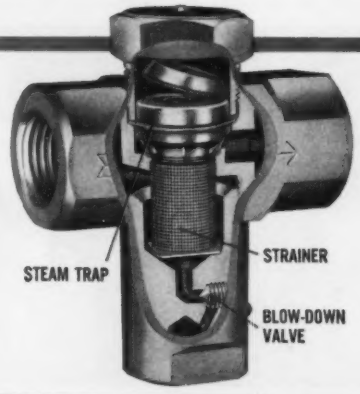
Here are a few typical user experiences:

TEXAS REFINERY—*Been using ½" No. 30's on drip legs to steam lines for 6 months. "No troubles whatsoever."*

PENNSYLVANIA TIRE MFR.—*Gradually replacing all traps on tire molds with Yarway No. 30's. "Amazed at their performance."*

MISSOURI STEEL PLANT—*Tested Yarway No. 30's against competitive traps, with result "Yarway No. 30 now standard on all main steam header drips."*

So it goes in plant after plant. Why don't *you* try Yarway Series 30 Traps? Available in ⅜" or ½" size; pressures 8 to 600 psi. Your nearby Industrial Distributor carries them. Write for his name.



NEW! COMPACT COMBINATION

NEW SERIES 130 steam trap combines a Series 30 trap, a strainer, and blow-down valve *all in one compact unit*—with these advantages:

- Saves space
- Saves weight
- Saves installation costs
- Saves on maintenance

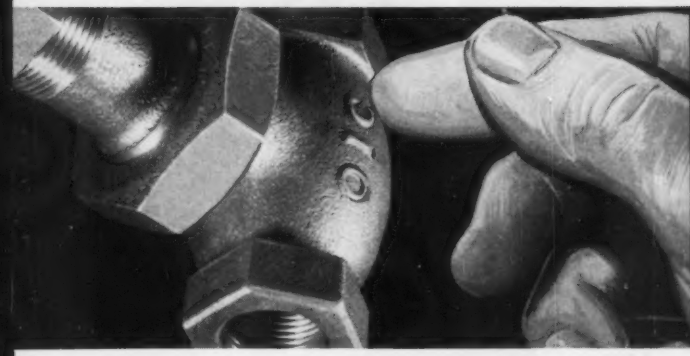
Stainless steel construction, good for all pressures 8 to 600 psi.

Your Yarway distributor has SERIES 130 traps. Try one today—or write for new Bulletin T-1743-B.

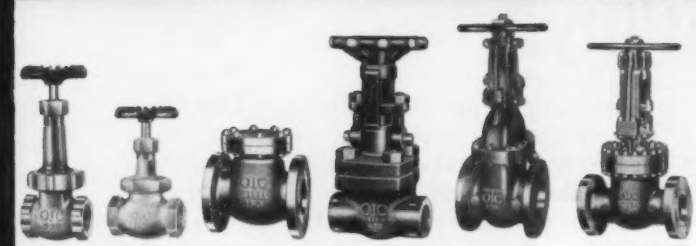
MEN WHO SPECIFY VALVES...

HEAR MORE ABOUT OIC VALVES!

SEE MORE AND MORE OIC VALVE INSTALLATIONS!



INSIST ON OIC FOR ALL VALVE APPLICATIONS!



You pay no premium for quality when you specify O I C. Special emphasis on design and manufacture . . . frequently in excess of industry specifications . . . assures you complete operational reliability, long life, reduced maintenance and easy access to vital working parts. A nation-wide distributor organization is ready and willing to advise you on the best valve for your particular application.

OIC VALVES

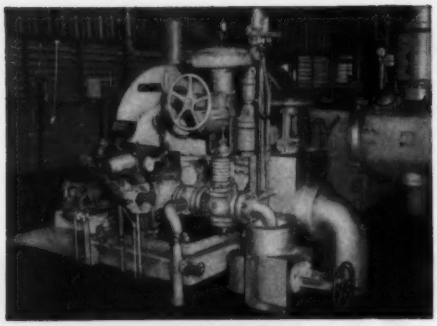
BRONZE, IRON, FORGED STEEL, CAST STEEL AND DUCTILE IRON VALVES

INDUSTRIAL DISTRIBUTORS SERVING INDUSTRY ECONOMICALLY THE RIGHT HAND OF PRODUCTION

THE OHIO INJECTOR COMPANY, WADSWORTH, OHIO

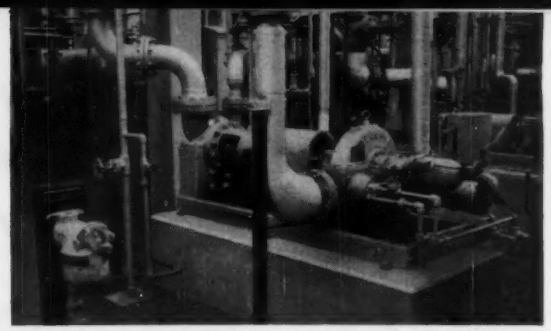
The Ohio Injector Company 10916-OIC
271 Main Street, Wadsworth, Ohio.
O I C quality is essential to my operations. Please send me complete information.

Name _____
Company _____
Product _____
Street _____
City _____ Zone ___ State _____

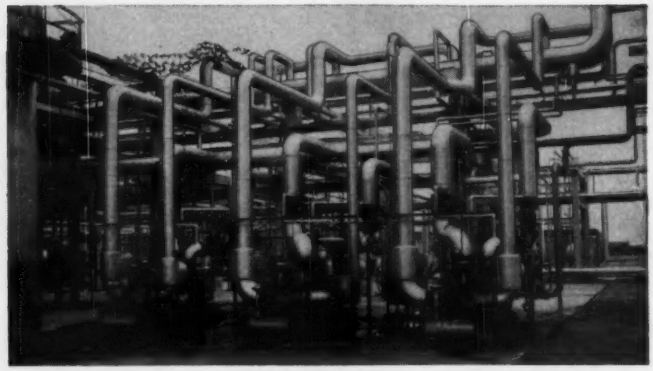


600-hp Elliott turbine driving a compressor which supplies compressed air for process.

(Right) Elliott steam turbines power many reflux pumps throughout the refinery. Shown here are three, driving gasoline column bottoms pumps in the crude unit.

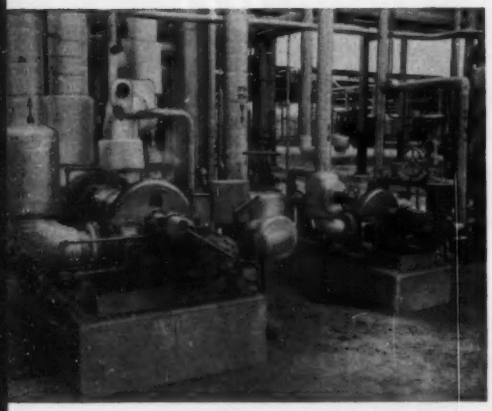


The YR turbine shown above drives an oil pump in the alkylation plant.

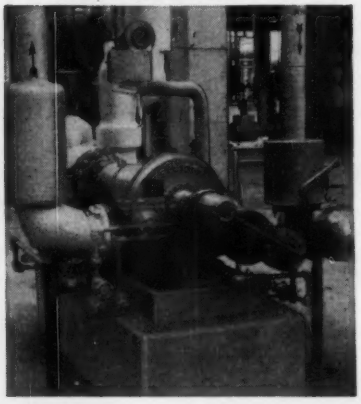


The turbine-driven condensate pump shown below charges foul condensate to stripper column.

Below are forced-draft fans driven by Elliott turbine-gear units in one of the refinery's boiler plants.



The unit on the left above is a condensate pump, and the one on the right is a seal oil and flushing oil pump. Both are driven by Elliott turbines.



FROM TURBINE HEADQUARTERS

In one refinery, 85 Elliott turbines driving pumps, compressors, fans prove Elliott versatility

Ranging in size from 5 to 935 horsepower, these Elliott YR single stage turbines are installed in a giant East Coast Refinery. The units were selected from a modern, field-proven line of mechanical drive turbines rated up to 50,000 horsepower.

Installations like this together with experience of more than 50 years in turbine design, manufacture and application are among the reasons why Elliott is truly "Turbine Headquarters." Write for descriptive bulletin H22-D. H1-2

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES · GENERATORS · MOTORS · COMPRESSORS · TURBOCHARGERS · EJECTORS · STRAINERS · TUBE CLEANERS

Regular Submersible

SUBMERSIBLE PUMPS

deliver water

economically

consistently

silently

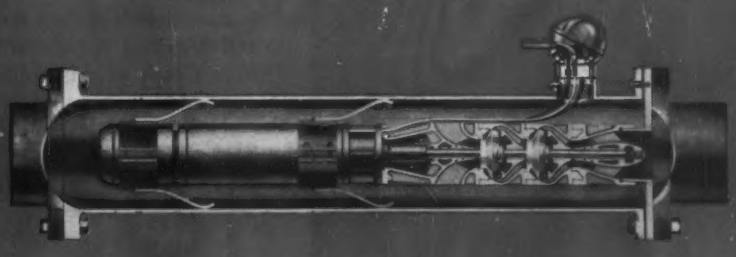
efficiently

The Layne Submersible Pump installation gives you noise free operation because the pump and motor are completely submerged. The Layne Submersible is adaptable to all wells; requires a minimum of space since no pump house is required; eliminates possibility of water contamination; and eliminates the opportunity for vandalism or other accidental mishap or damage.

Layne Submersible Pumps are available for wells as small as 6 inches and in capacities from 30 GPM up. For additional information write for free bulletin number 202.

The Layne In-Line Submersible pump provides the answer to many problems in booster pump applications. The pump operates as an integral part of the line and is designed for use by municipalities, industry, such as petroleum and chemical plants and by agriculture. Advantages include: simple installation, no additional space required, continuous service even under flood conditions, and no possibility of surface water contamination.

Layne In-Line pumps are made as small as 4 inch bowls on a 4 inch motor for use in a 6 inch pipe to deliver 30 GPM. Larger sizes are available as required. For additional information write for free bulletin number 203.



In-Line Submersible

Layne SINCE 1882 — COMPLETE WATER SERVICE

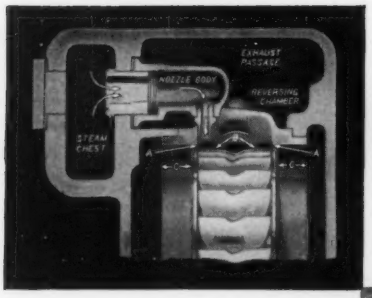
LAYNE & BOWLER, INC., MEMPHIS

General Offices and Factory, Memphis 8, Tenn.

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

Sales Representatives in Major Cities

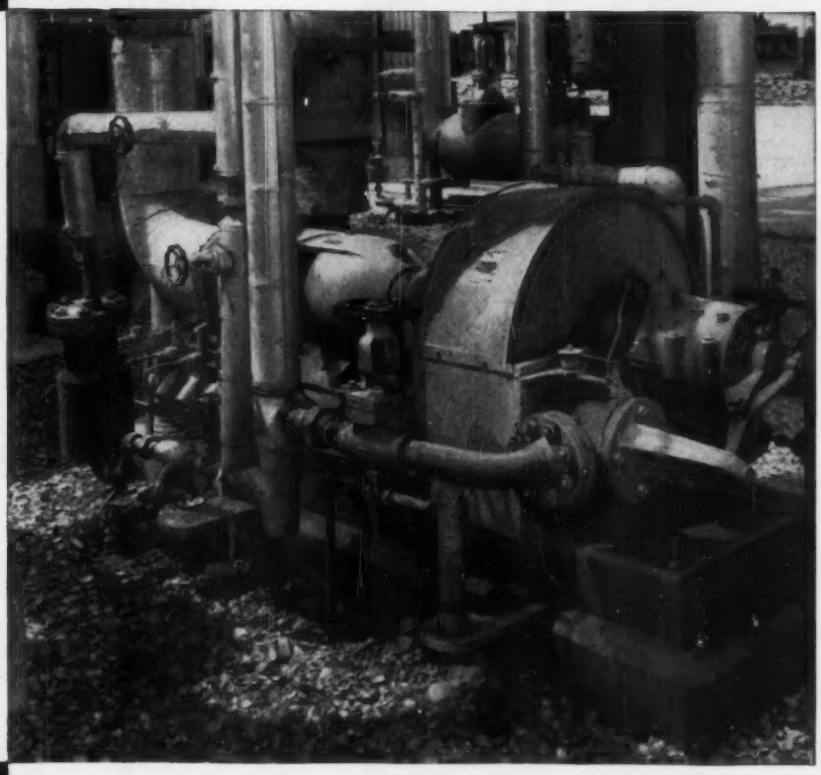
Find LAYNE Fast in the Yellow Pages under pumps



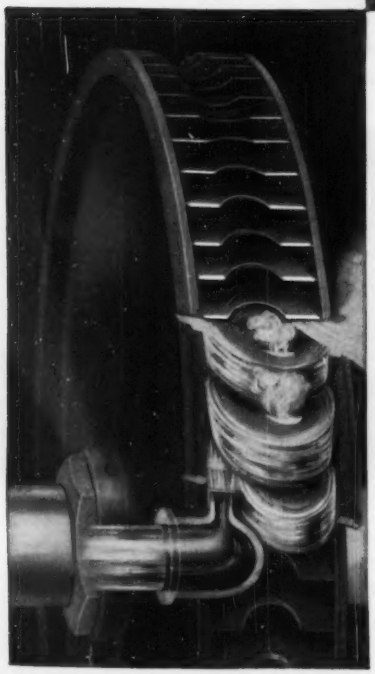
TWO REASONS WHY

this turbine seldom sees down time

1 ***Generous wheel clearances:*** AA —rim clearance, B—blade clearance, CC —side clearance. Blades can't foul as they are protected by rims. Rubbing at AA will do no damage. Side clearance is so large (about one inch) that end-play from excessive external thrust cannot damage wheel.



2 ***Blade wear is of little consequence.*** In a Terry solid-wheel turbine, the steam enters the buckets at right angles to the shaft. As its power-producing action takes place on the curved surfaces at the backs of the buckets, wear does not materially affect horsepower or efficiency.



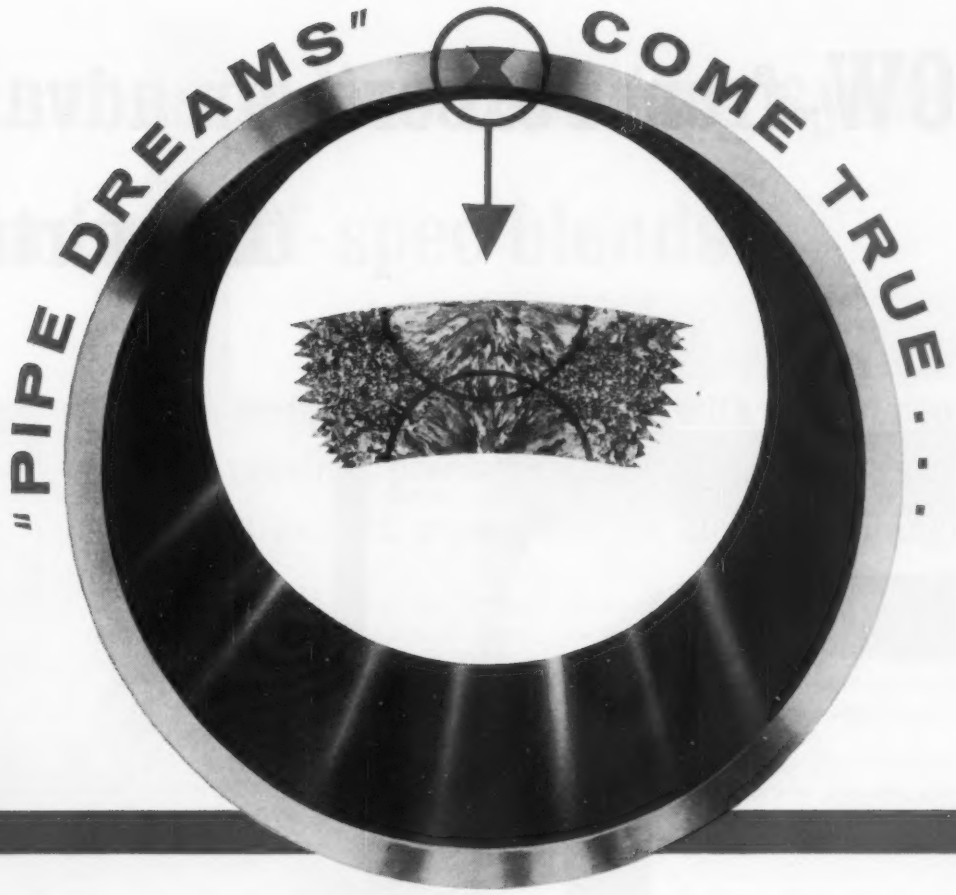
To prevent costly shutdowns for repairs, Terry builds bonus reliability into each solid-wheel turbine. Two of the ways in which this is accomplished are shown in the diagrams at the left.

Further details of these simple, fool-proof turbines are illustrated and described in bulletin S-116. If you do not already have a copy of this publication, send for one today. No cost or obligation.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1217

TERRY



WITH SWEPCO'S NEW SYNCRO-WELD® LARGE DIAMETER STAINLESS STEEL PIPE

The Most Advanced in the Industry

Syncro-Weld assures smoothness and strength never before attainable in welded pipe.
You get these six advantages:

1. Synchronized fusion on both O.D. and I.D.
2. No root bead problems
3. Smoother on O.D. and I.D. than commercial pipe
4. Uniform weld assures ductility under extreme working conditions
5. Greater fatigue strength and efficiency
6. Increased service life expectancy

Mill-processed Syncro-Weld pipe is available now "off-the-shelf" from 5" I.P.S. to 12" I.P.S. in Schedules 5 and 10 at all 72 Swepco Distributor Steel Service Centers.

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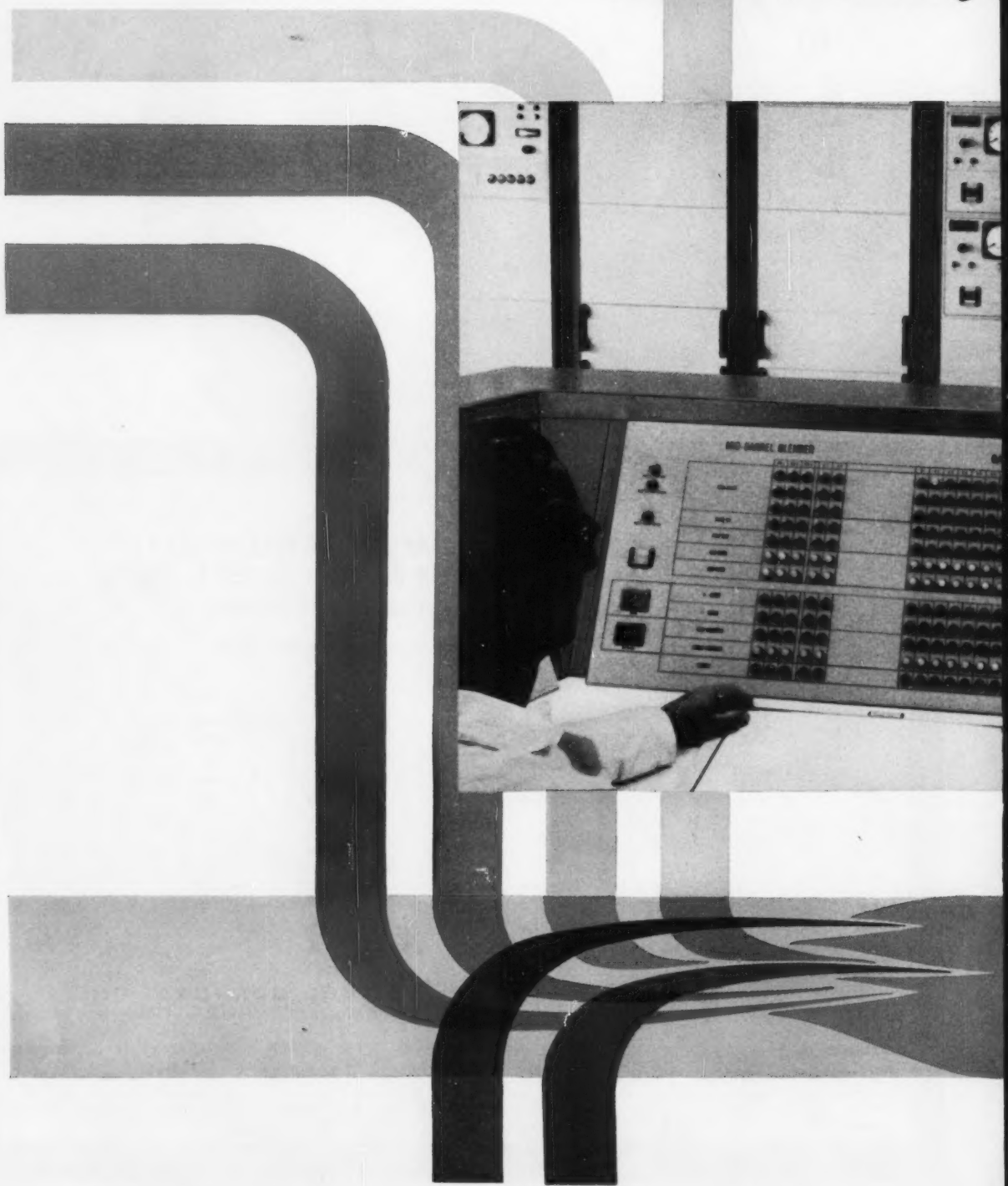
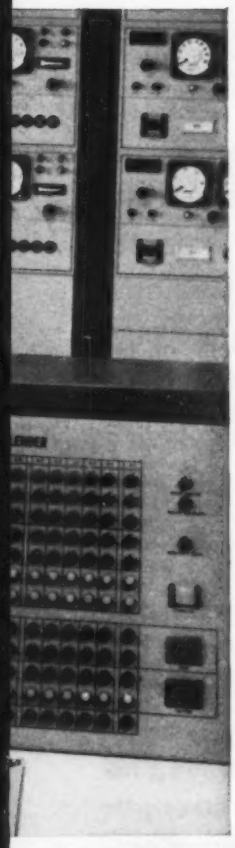
NOW - from Foxboro - an advanced

that virtually



continuous in-line blending system eliminates off-spec blends



At Union Oil's Los Angeles refinery the engineering techniques behind the Foxboro-Waugh Blending System already have been proven.

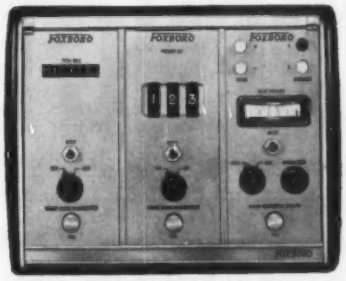
Foxboro-Waugh Blending System*, with digital control, provides precision blending accuracy... permits instant, remote-control blending changes

With acquisition of the Waugh Engineering Company, Foxboro now brings to the petroleum industry a new, high precision blending system that increases the efficiency of continuous in-line blending. It's the Foxboro-Waugh Blending System — with an overall accuracy that virtually eliminates off-spec products.

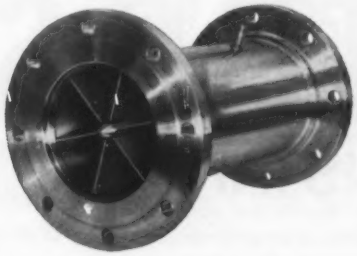
The Foxboro-Waugh Blending System lets you mix a wide variety of refined oil products — continuously, automatically, with precision accuracy — right in the pipeline!

With the Foxboro-Waugh System you change blends quickly — right from the control panel. No more batch mixing. No more waiting for blend tanks. No more time-consuming trips to the field to turn valves for a blend change. The system allows checking product quality without waiting for the end of the blend.

Find out how your plant can strip away thousands of dollars of tankage, reblending and other operating costs with the Foxboro-Waugh Blending System. Write for Bulletin 10-27. The Foxboro Company, 7411 Neponset Ave., Foxboro, Mass., or Waugh Engineering Division, 7740 Lemona Ave., Van Nuys, Calif.



Foxboro-Waugh solid-state Standardizer, Ratio Selector, and Digital Controller provide instant, dependable blending control.



Unique Waugh Turbine Flow Meter transmits digital signals with accuracy as low as ±0.25% and repeatability of ±0.10%.

*An electronic blending system developed jointly by Union Oil Company of California and Waugh Division of Foxboro.

FOXBORO
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For more data on advertised products, use cards, last page.

Read about the most important development

A recent Cyclone Fence development promises to revolutionize industrial fencing throughout the United States. After years of vigorous research, and production line debugging, we are manufacturing an aluminum-coated steel fence of such high quality that we are willing to give it the Cyclone name. Nine years of field testing indicate that no other type of fence can economically match Cyclone Aluminum-Coated Fence's combination of corrosion resistance, tensile strength and heat resistance. Yet the price is only slightly above first-quality galvanized steel fence.

FIRE RESISTANCE

In a brush or debris fire, not uncommon along a fence line, temperatures can easily climb to the 1,300° mark. If the fence fabric melts, your property protection goes with it. The steel in Cyclone Aluminum-Coated Fence will not melt at temperatures below 2,850°. Repeated tests have shown that our aluminum-coated fabric can withstand temperatures as high as 1,650° and still retain its protective coating, and 2,000° for brief periods without the destruction of a single strand of wire.

STRENGTH

The steel wire used in Cyclone Aluminum-Coated Fence has a minimum tensile strength of 80,000 psi, and that strength is retained as long as the coating remains intact. What does this strength mean to you? In actual tests, USS Cyclone Aluminum-Coated Fence was rammed by a car traveling at 35 mph. Not a single strand of wire was broken. ■ Buyers must not underestimate the necessity for strength in industrial fence. If you could "fence your fence" to protect it there would be no problems. But fence has to stand alone, and withstand vandals, side-swiping vehicles, and all sorts of mechanical abuse.

Protect it with USS CYCLONE

in the history of property protection fence

CORROSION RESISTANCE

Our Research and Metallurgical people have found accelerated weathering and salt spray tests are misleading, therefore the following data is from actual service records: After 9 years of continuous exposure to a severe industrial atmosphere (Cleveland), Cyclone Aluminum-Coated Fence shows practically no deterioration. Even after 9 years of severe marine exposure, 90% of the surface was free of corrosion.

PRICE

The normal market prices for USS Cyclone Aluminum-Coated Fence are only slightly above prices for galvanized chain link fence. And remember, for this very slight premium you're getting the combination of aluminum and steel that gives you superior corrosion resistance and long lasting strength.

KNOW THE BRAND

Cyclone is a brand name, not a type of fence. When you buy USS Cyclone you're getting a fence that's pre-engineered, prefabricated down to its smallest part. The Cyclone-developed H-Post is built like a steel beam for extra strength; Cyclone gates are sleeve-constructed—not welded—so they can be easily repaired; one-quality, full-weight fabric; deep-set post installations that don't skimp on concrete or steel, and professional installation by long-time Cyclone crewmen who know how to put up a fence to stay. ■ USS Cyclone has sales offices all over the country and a reputation built on the fact that Cyclone is the most widely used property protection fence in the world. Cyclone Fence is backed by the American Steel and Wire Division of United States Steel—a company that will be around tomorrow to live with what it sells today. ■ 69 CYCLONE BRANCH OFFICES. Cyclone has 69 branch offices throughout the country. Which means, wherever you are, we're reasonably close by. Give us a call next time you need fence around your company's property. Check your Yellow Pages under "Fence." For a brochure on new Cyclone Aluminum-Coated Fence, write American Steel and Wire, Rockefeller Building, Cleveland 13, Ohio.

USS and Cyclone are registered trademarks.

For safety, dependability, economy.

American Steel and Wire Division of United States Steel

"Bob, the computer analysis says we should buy those parts instead of making them"

NEW CAPITAL INVESTMENT PROGRAM

Here's a new IBM computer program that's yours for the asking. Using the Investors Method (Rate of Return on Investment), it helps you evaluate—*quickly, economically, uniformly*—alternate proposals for spending your company's money.

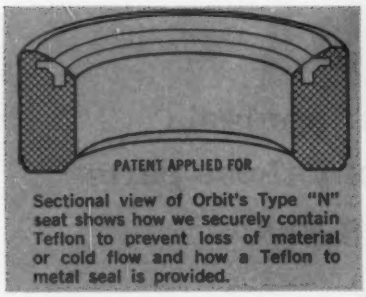
The program will help you solve problems like these: should you buy a new piece of equipment or keep the old one in repair; should you increase your manufacturing facilities; should you buy or make certain products; how should you spend your money for research to make the most profit?

These are only a few of the problems that the Capital Investment Program handles. All it takes is the Program and an IBM computer that accepts FORTRAN programming language. The low cost IBM 1620 Data Processing System is one such computer.

The new Capital Investment Program is another of the many problem solving programs IBM offers you to help make your data processing system a more effective and more profitable tool for managing your business.

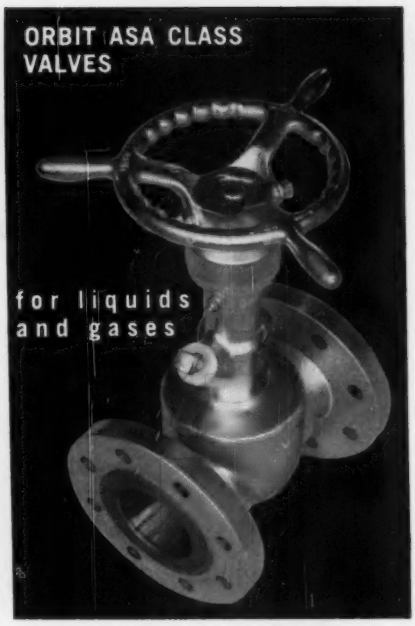
Your local IBM Representative can give you complete details on this, as well as previously announced programs, which included Sales Forecasting, Materials Planning, Inventory Management, Plant Scheduling, Work Dispatching, Operations Evaluation, Inventory Management Simulation, and many others.

IBM®
DATA PROCESSING



PATENT APPLIED FOR

Sectional view of Orbit's Type "N" seat shows how we securely contain Teflon to prevent loss of material or cold flow and how a Teflon to metal seal is provided.



ORBIT VALVES COMBINE THREE PROVEN SEATING PRINCIPLES IN ONE VALVE SEAT

The ORBIT Value seating principle is best described as employing: (1) Globe valve seating, (2) Wedge valve action, (3) Plug valve rotation — all three principles are combined to provide Friction-Free seating plus Full Round Straight thru flow, and to eliminate normal valve wear problems, and to provide long valve life, yet no lubrication is required for a shut-off. Valve replacement problems are minimized.

The body seat is designed with a convex seating surface formed by the Teflon and metal — this provides for absolute shut-off and assures positive closure under severe conditions. The Teflon is so contained that it is not affected by high differential pressures flowing across the seat. Normal manufacturing tolerances as well as normal valve wear are compensated for by the resilient Teflon material. ORBIT Valves comply to ASA Pressure Temperature Ratings.

FOR LIQUIDS and GASES

3 in 1

ORBIT TYPE "N" BODY SEAT WITH MOLDED TEFLON* FEP RESIN PROVIDES:

(1) resilient seating with metal-to-metal back-up

(2) friction-free seating

(3) seating without lubrication

TYPE "N" BODY SEAT HAS 400° Fahr. MAXIMUM TEMPERATURE RATING.

*Telfon is duPont's registered trademark for its family of fluorocarbon resins, including FEP resin.

FOR 400° Fahr. SERVICE GOOD SIZE RANGE VENTURI and FULL ROUND OPENING ASA 150 lb. thru ASA 2500 lb. AND for 450° Fahr. SERVICE IN RATINGS ASA 150 lb. thru ASA 600 lb. CLASS

For additional information write for our Catalog 61-B.

ORBIT VALVE COMPANY

P. O. Box 699 Tulsa, Oklahoma Phone LU 4-4761 TWX TU 925

ORBIT VALVES

Finding a path through today's antiknock maze

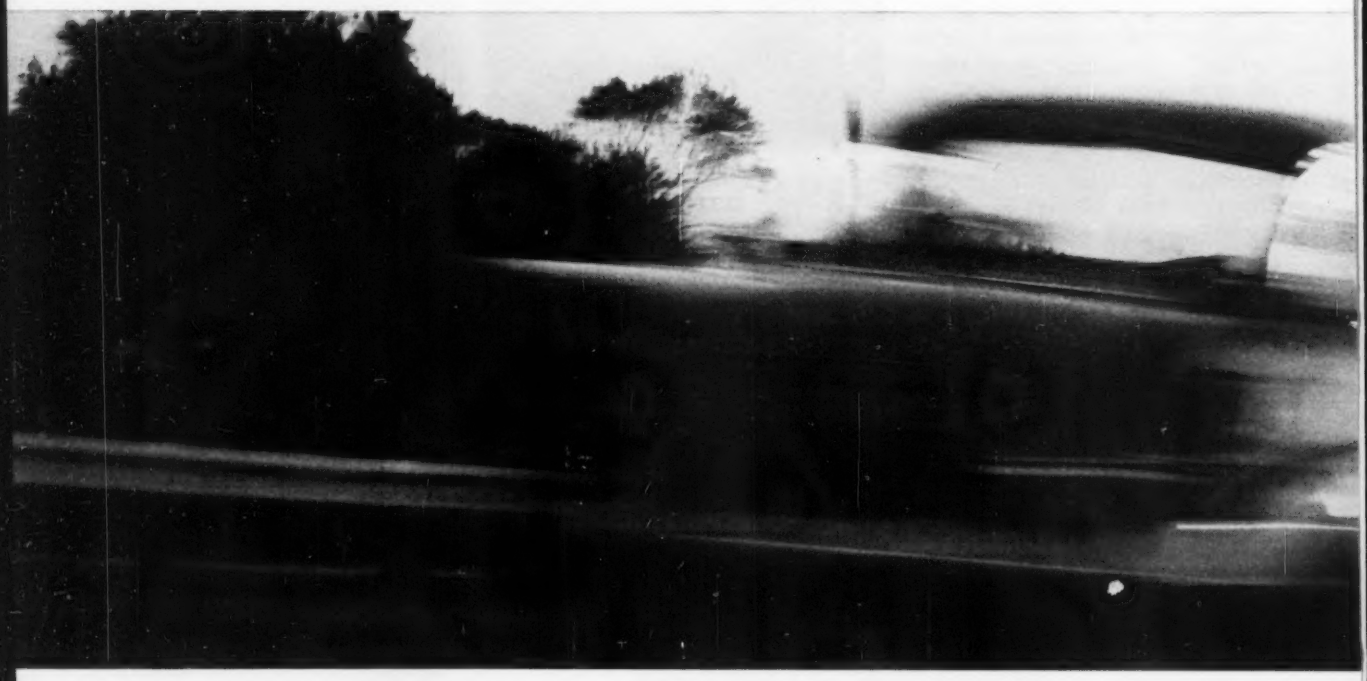
Which antiknock would *you* choose for a standard, compact or economy car? For a low or high compression engine? For a stick-shift or automatic transmission? For 4, 6 or 8 cylinders – straight or V? To help refiners choose the best antiknock for *each* blending requirement at the lowest cost, Du Pont is in the midst of a continuing study of the variables involved. For an up-to-now report on that study,

turn the page...

■ *A recent Du Pont study showed one refiner how he could save $19 per 1,000 barrels of regular gasoline and $64 on his premium grade by changing antiknocks.*

■ *Another refiner could save $15 on regular and $20 on premium.*

■ *The same Du Pont study that made these and other such success stories possible may help YOU sort out the variables that control antiknock selection today, yielding the octane rating you want at the lowest price possible.*



How Du Pont research helps refiners choose the right antiknock for each situation

Wilmington, Del.: The Du Pont Petroleum Laboratory is currently in the midst of a continuing program comparing the antiknock performance of TEL, TML and TETRAMIX* lead alkyl mixtures in a variety of fuels.

This study has already paid off for a number of refiners, by showing which of the many available antiknocks can do the best job of octane improvement *per dollar spent*.

As refiners are well aware, performance of the "new" antiknocks varies greatly from fuel to fuel and from engine to engine. Road octane values can differ greatly from Research and Motor octane results. A full testing program must be conducted on every fuel before the refiner can safely say, "*This* antiknock is best for my fuels".

Du Pont's continuing research provides such assistance.

PROBLEM: How Volatile?

The gasoline you sell to the driver of a stick-shift, 4-cylinder compact may need a different antiknock than that used in an automatic-shift V-8. The Du Pont study has thrown dramatic light on the significance of the differences in volatility of TML, "TETRAMIX" and TEL – and the need for greater volatility in the fuel distribution systems of certain groups of cars. TML and "TETRAMIX" are more volatile than TEL, and have clear-cut advantages in attaining desired Road Octane values in such automobiles.

PROBLEM: What Concentration?

Further results of this study show that, of the new

antiknocks, TML is generally most useful in manual transmission cars with fuels having low front end octane quality. "TETRAMIX" provides advantages over TEL in a variety of fuels, with its advantage increasing at higher octane and lead levels and higher aromatic contents.

PROBLEM: How Many Dollars?

Out of all this research comes the practical advantage of learning exactly which antiknock will work best in your fuel on the basis of overall cost. As a rule, the study indicates that TEL is still the most economical antiknock with respect to both Research and Road octane number in most fuels, with "TETRAMIX" proving best for a significant number of fuels and TML winning out in isolated cases.

More Details Available

Our Petroleum Laboratory is prepared to share this study with oil refiners and marketers, and to work individually with you on choosing the most economical antiknock for your fuel. For further details, contact your Du Pont representative. E. I. du Pont de Nemours & Co. (Inc.) Petroleum Chemicals Division, Wilmington 98, Delaware. * Trademark

Antiknocks and other Petroleum Additives

DU PONT
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Better Things for Better Living
... through Chemistry

How Wheeling Steel bought safety... gained efficiency with Cellulube 300

Mr. Kenneth N. Bundy, Superintendent of Utilities Department, Steubenville Works, Wheeling Steel Corporation is responsible for the safe and efficient operation of power house equipment. Air compressor lubricant is fire-resistant Cellulube 300.

Two of three 100 psi. air compressors in power house at Wheeling Steel. Not a single air-compressor fire has occurred at this installation since Celanese fire-resistant Cellulube 300 has been used as the lubricant.

Compressor fires were troublesome before Celanese Cellulube was used in three dual stage, 100 psi. air compressors in the power house of Wheeling Steel's Steubenville Works.

To stop this fire problem, Celanese recommended Cellulube 300. And, since use of this fire-resistant fluid was initiated more than five years ago, there has not been a single fire in any of the compressors! What's more, substantial savings have been gained through reduction in maintenance.

Celanese Cellulubes, available in six controlled viscosities, prevent build-up of hard car-

bon deposits. Cleaner operation eliminates the need for cleaning compressor auxiliaries and greatly reduces frequency of valve cleaning.

Cellulubes give overall protection against wear comparable to that of premium petroleum oils.

Doesn't it make sense to investigate what fire-resistant Cellulubes can do for you in terms of both safety and efficiency? The coupon will bring you complete details. Celanese Chemical Company, 522 Fifth Avenue, New York 36, N. Y.

Celanese® Cellulube®

Celanese Chemical Company is a Division of Celanese Corporation of America
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co. Inc., and Pan Amcel Co., Inc., 522 Fifth Avenue, New York 36

Celanese
CHEMICAL COMPANY

CELANESE CHEMICAL COMPANY
Dep: 574-K, 522 Fifth Avenue, New York 36, N. Y.

Rush data on Cellulubes.

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

My applicaiion for Cellulubes is_____

NEW SLANTS ON HEAT PROCESSING FROM SELAS

Oxo-Synthesis Gas and hydrogen produced simultaneously in new GULF furnace

An outstanding feature of Gulf Oil Corporation's new oxo alcohol plant in Philadelphia, Pa., is the unique design of the Selas furnace which permits simultaneous production of synthesis gas and relatively pure hydrogen, in one firebox containing no internal partition walls.

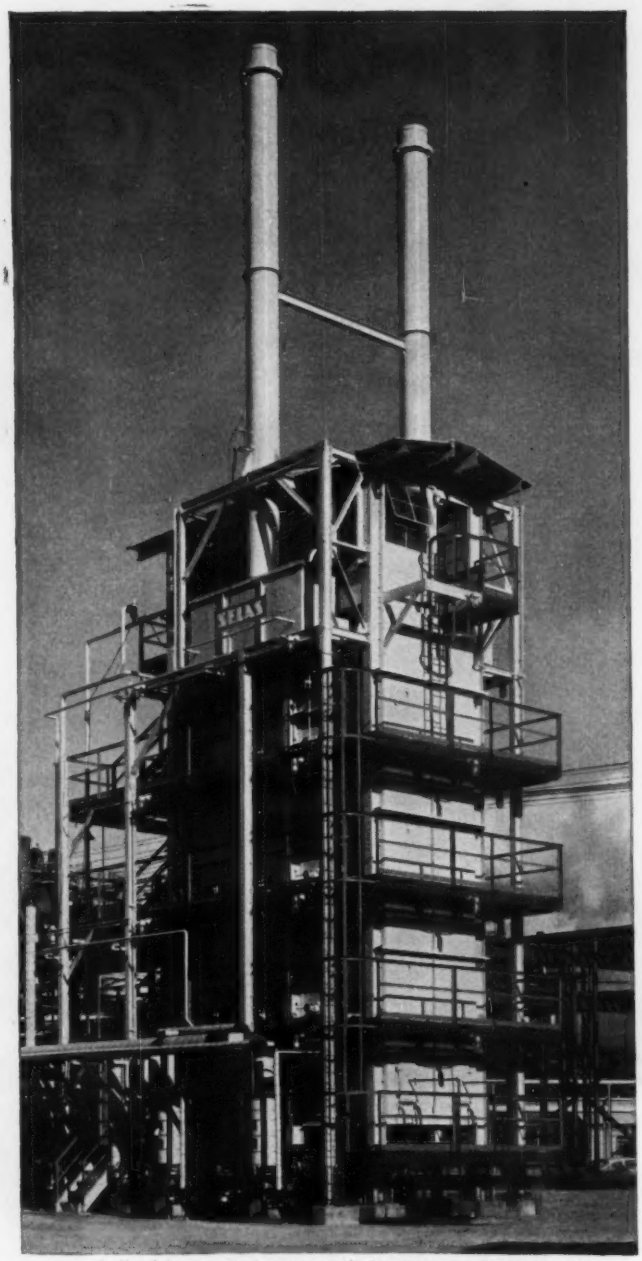
A variation of the Selas GRADIATION® furnace widely used for ethylene and hydrogen production, this design utilizes DURADIANT® burners which focus energy on the process coil, thereby permitting use of two or more process coils—operating at different conditions—in the same firebox.

Through use of multiplicity of strategically-located burners in the Selas furnace, horizontal bands, or zones, of radiant energy are created. Result: close control of critical tube wall temperatures down the length of the vertical catalyst-packed tubes in the process coil.

Two similar Selas furnaces will soon go into oxo-synthesis service in other petrochemical installations.

Technical details on the application of this type Selas unit for production of hydrogen, methanol-synthesis gas, and oxo-synthesis gas are contained in a paper "What's New in Steam Methane Reformers," presented by Selas engineers at the A.I.Ch.E. annual meeting, February 26, 1961, in New Orleans.

Copies of this paper are available. Write to Fluid Processing Division.



Gulf Oil Corporation's new oxo alcohol plant was designed and constructed by Badger Manufacturing Co.

SELAS CORPORATION OF AMERICA
711 Dreshertown Road, Dresher, Pa.

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SELAS

HEAT AND FLUID PROCESSING ENGINEERS

DEVELOPMENT / DESIGN / CONSTRUCTION

NEW CHIKSAN SPRING BALANCED LOADING ARM—

Here is a series of loading arms that is built to deliver solid performance right around the calendar. Outstanding new compression spring design offers finger-weight flexibility, yet the arm will not creep or sag when released. Springs are housed in a sturdy weatherproof steel case. Balance adjustments are accomplished with a hand wrench. The swivel joints on the arm have the dependability that has been associated with the name Chiksan for 30 years. Get the facts. Write for Bulletin 1-61.

FEATURING NEW TOTALLY ENCLOSED COMPRESSION SPRING—

Self compensating spring tension provides complete balance at any position. Compact design. No protruding brackets or counterweights.

4 MODELS FOR PETROLEUM SERVICE

Select from a complete line. All models—Folded Arm, Sliding Sleeve (shown above), Bottom Loader and Long Reach are available in 2, 3, and 4-inch sizes. Each model is a complete, ready for service, unit.

2 MODELS FOR CHEMICAL SERVICE

For loading or unloading virtually any chemicals, Chiksan offers a standard group of arms equipped with its DS series swivel joints. Available in Folded Arm model or Sliding Sleeve unit (shown at left).

WANT TO CONVERT EXISTING EQUIPMENT?

Chiksan Base Arm Sections permit operators to change existing facilities with minimum effort. Base Arm Sections are available in standard sizes of 2", 3", and 4". Riser joint supplied with threaded or flanged connections.

MAIL COUPON TODAY FOR COMPLETE INFORMATION

CHIKSAN

fmc

#61-60

CHIKSAN COMPANY
330 North Brea Blvd., Brea, Calif.

Please send me your Bulletin 1-61.

Name_____

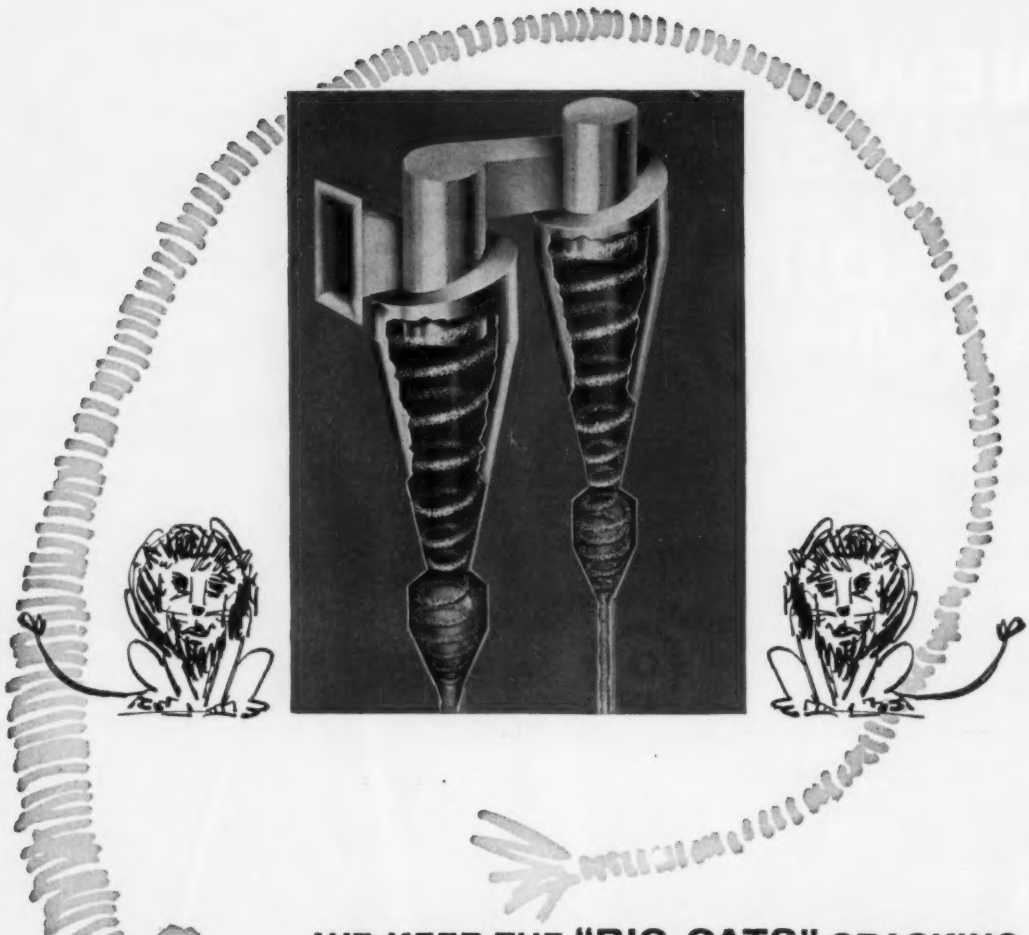
Title_____

Company_____

Address_____

City_____ Zone_____ State_____

CHIKSAN COMPANY—General Offices: Brea, California • Well Equipment Mfg. Corp. Division (Weco Unions, Hamer Valves) • Chiksan International • Chiksan of Canada Ltd.
Offices and Representatives in Principal Cities of the World



WE KEEP THE "BIG CATS" CRACKING

The "Big Cats," those steel behemoths that work wonders with the gasoline molecule, have a wild streak in them. Unless kept under control they can whip up a storm of flying catalyst dust that raises havoc with the operation and brings the Air Pollution Control people running.

To avoid this embarrassing and economically hazardous situation, refiners install our high efficiency SDC Duclones and Trickle Valves. They save money . . . improve performance . . . and in general do an admirable job. They snare each flying catalyst particle and plummet it back into the fluid bed to perform the miraculous task of catalytic cracking.

Is it any wonder that Duclones were used in two large refineries which set records for continuous on-stream service.

For more information on how SDC Duclones can keep "Big Cats" cracking, send for bulletin C-2058.

the name in DUst CONtrol

THE Ducon COMPANY, INC.

147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

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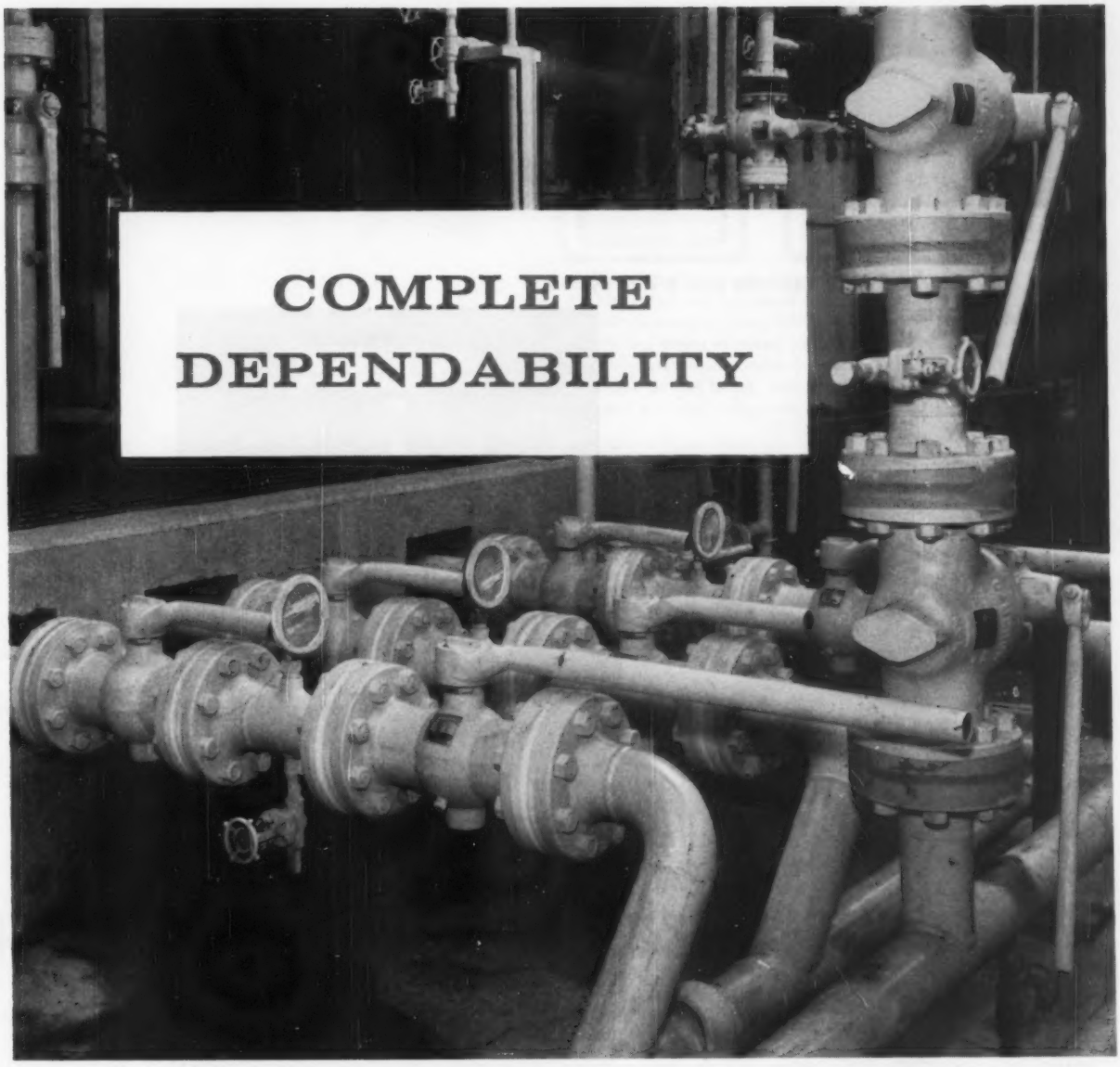
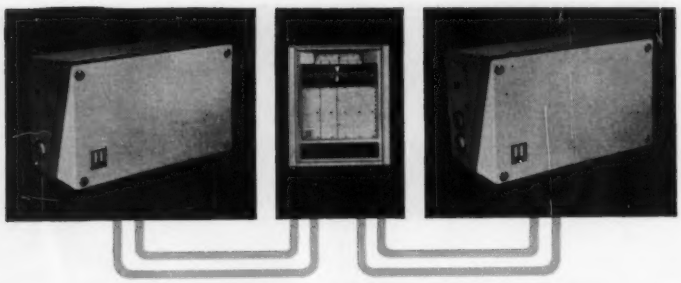


Day after day, month after month, Cameron Ball Valves operate easily and give a tight shut-off. They require no attention from the maintenance men because they are not lubricated, they never stick and there are no glands to require repacking.

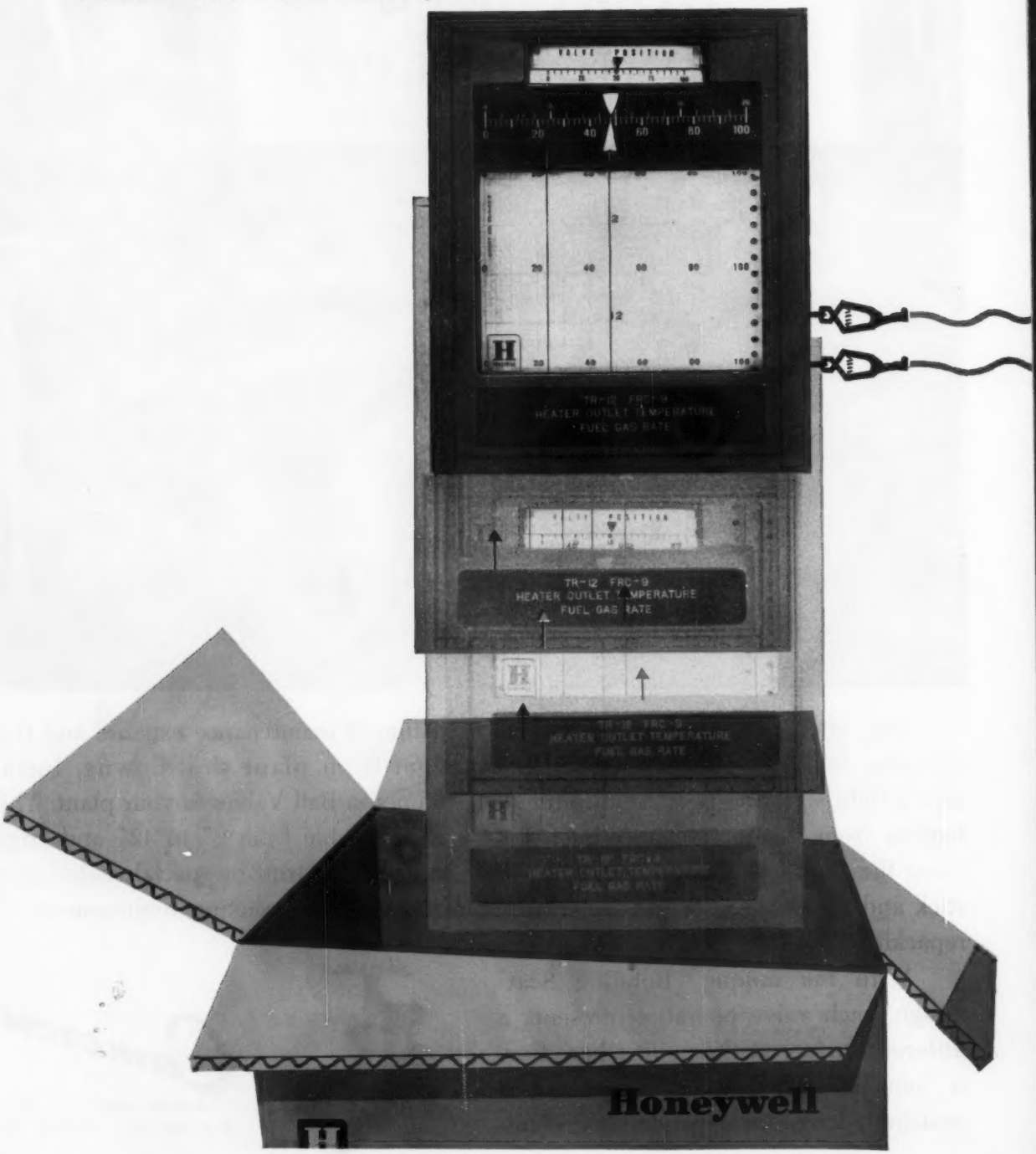
With the unique "Rotating Seat" design, each valve operation presents a different surface at the point where flow is "pinched off" and valve seat life is amazingly long. For dependability, elimination of maintenance expense and freedom from plant shut-downs, install Cameron Ball Valves in your plant. They are available from 2" to 42" and larger in standard trim or special materials to fit your most exacting requirements.

Cameron

CAMERON IRON WORKS, INC.
P. O. BOX 1212 HOUSTON, TEXAS



***ElectriK Tel-O-Set*—the true 2-wire system**



This "Loop Snooper" adds to the extraordinary ease of installation and maintenance you'll find in the *ElectriK Tel-O-Set* System. It's a portable test instrument that can accurately check . . . from the control panel . . . any *Tel-O-Set* unit in the field, to make sure signals are being received and sent exactly as they should be. Or it can operate and check a recorder chassis, indicator chassis or controller on the bench, with local power. The "Loop Snooper" removes trial and error from installation and maintenance.

SIMPLEST TO INSTALL, ADJUST AND MAINTAIN

The *ElectriK Tel-O-Set* System has many features that save time in getting on stream, and keep maintenance to a minimum. For example, all process connections are isolated from the inside of *Tel-O-Set* transmitter and transducer cases, so that you can mount, pipe and wire the instruments without removing their covers. Instrument chassis can be removed for servicing without breaking any external process or electrical connections. Standardized parts and extensive use of quick-connect and plug-in design cut downtime and spare parts requirements.

No external power is required at any field-mounted *Tel-O-Set* instrument; line power is connected only at the receiver. Two-wire d-c transmission eliminates shielding and further reduces installation costs. The 4-20 milliamp signal range gives a *live* zero through the use of readily available reliable transistors.

Your nearby Honeywell field engineer can tell you how *ElectriK Tel-O-Set* advantages relate to your particular control requirements. Call him today . . . he's as near as your phone. Or write to MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

First in Control

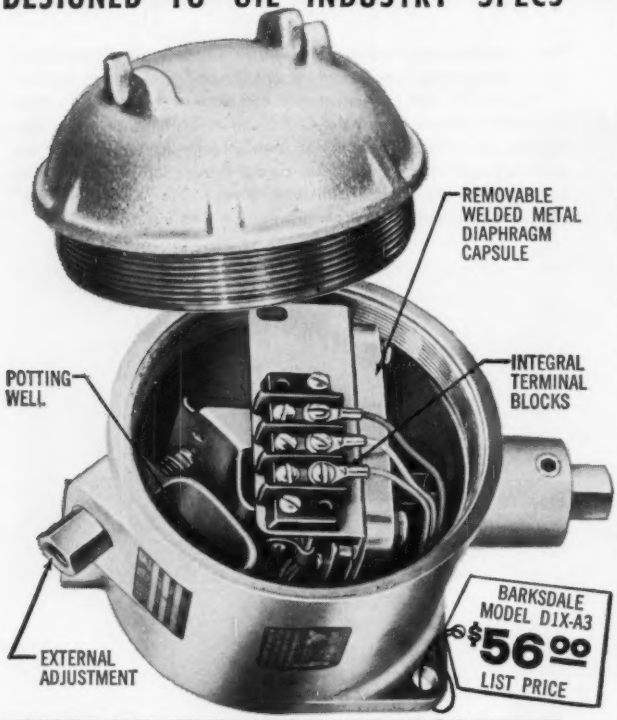
SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

INSTRUMENT ACCURACY (± ½ PERCENT)

EXPLOSION PROOF PRESSURE SWITCH

DESIGNED TO OIL INDUSTRY SPECS



WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

PRESSURE SWITCH DIVISION

ASK FOR HANDBOOK & CATALOG 61-62

Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

Improved design, reduced prices

New Barksdale diaphragm pressure switches incorporate the improvements most frequently requested in personal consultations with leading production men in the petroleum and other major industries before designing was begun. Improved switch accuracy, higher proof pressures, and important installation and servicing economies are direct results reflected in Barksdale explosion proof models. Employment of the erector set principle of construction (compact basic diaphragm unit with optional housings) permits production savings that make possible substantially lower prices.

Instrument accuracy of ± ½ percent

Accuracy of ±½% as compared to the customary ±1% is guaranteed, and each unit is tested for repeat accuracy of set point and re-set point before shipment.

Proof pressures to 500 psi

In the low settings Barksdale explosion proof pressure switches will actuate at 0.1″ mercury with proof pressure to 10 psi. In higher ranges they will go up to 500 psi proof pressure at settings to 400 psi.

Removable diaphragms

As diaphragms may be removed, substitutions can be made readily to accommodate varying pressure requirements or to install diaphragms of different metals as fluid characteristics may demand. This exchangeable feature is important when servicing for paraffin accumulation as field personnel need carry only the diaphragms (not entire switches). Integral terminal blocks facilitate removal of switches in making diaphragm substitutions.

External adjustment

Explosion proof switches (single setting or dual control) may be adjusted externally. Recessed screwdriver adjustment openings are made tamperproof by insertion of threaded safety plugs.

Additional Barksdale features

Pottable electric outlets.

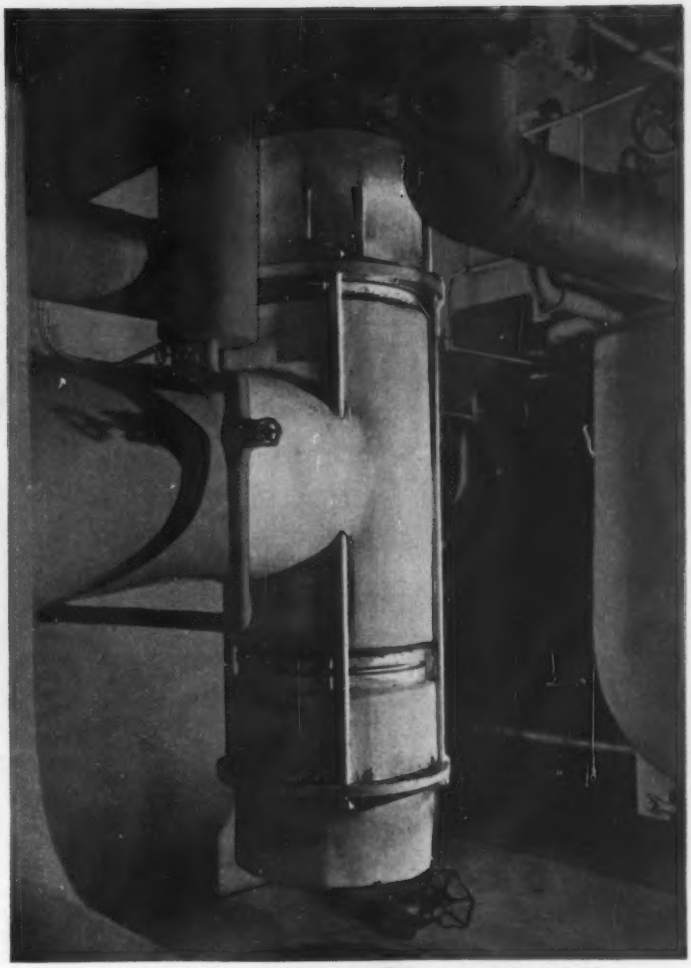
Housings are independent of the sensing and switching mechanisms. Ambient temperature will not throw switches out of adjustment.

Servicing instructions are on the inside of housing cover to allow for painting of the units.

Ask for Handbook and Catalog 61-62

Complete details on Barksdale diaphragm, piston, and bourdon tube pressure switches are included in a new handbook and catalog. This free book is a practical aid in planning the vital link between your electric and hydraulic circuits. It contains a glossary of terms, a schematic demonstration of operating characteristics, and a suggested step-by-step procedure for simplifying pressure switch selection. In addition, there is a complete run-down on all the detail features leading to the unit that answers your specific control problems. Write for Handbook and Catalog 61-62, or ask your Barksdale representative.

In the foreground, a 20" ZALLEA Universal Expansion Joint absorbing lateral movement.



At a major Eastern oil refinery, a 20" Zallea Pressure Balanced Expansion Joint installed on a steam turbine exhaust nozzle.

it's ZALLEA for maximum reliability... the tough jobs show why

Six tough Zallea Expansion Joints protect three 10,000 kw turbine generators from the wallop of thermal stresses . . . real hot-spot duty. Each generating unit has a 20" pressure balanced, self equalizing expansion joint installed at the turbine exhaust nozzle to absorb reaction load due to internal pressure acting against the turbine casing. A 20" universal expansion joint absorbs lateral deflection in the pipe run from the pressure balanced unit. Temperatures range from 0° to 615° at start-up, back to 475° in operation, at 200 psig. To cope with these cycles, the turbines demand—and get—the maximum reliability of Zallea Expansion Joints.

Whatever the service, none of the many factors affecting Zallea Expansion Joint reliability are left to guesswork. Zallea Expansion Joints are hydraulically formed. Advanced welding techniques insure welds having the same thickness, strength and physical properties as the parent metal. Zallea has done more cyclic testing to destruction than all government agencies and industrial firms combined. Zallea has produced more expansion joints than any other manufacturer . . . offers you more application engineering experience. These are just a few of the reasons Zallea Expansion Joints can and do outlive the equipment they serve. Sooner or later, ordinary expansion joints hand you a bill for unscheduled downtime, lost output.

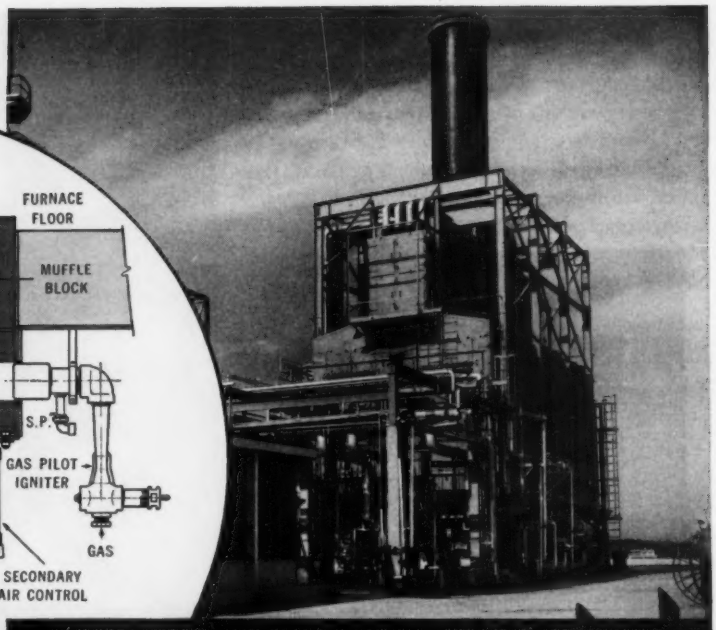
Got a tough one coming up? Call in an experienced Zallea design and application specialist. Knows every inch of his product, can assist with every facet of your problem. And write for catalog 56, Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

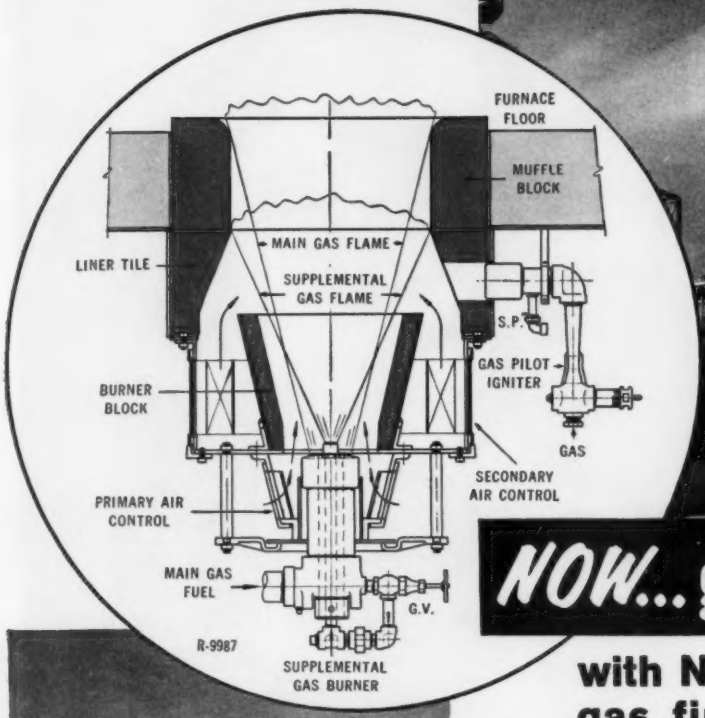
Zallea

for maximum reliability

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

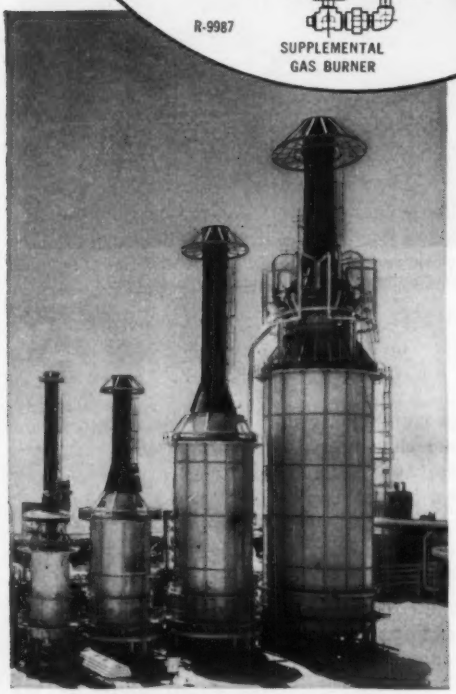
For more data on advertised products, use cards, last page.





NOW... greater VERSATILITY

with National Airoil C. P. gas firing burner units



Throughout the world . . . in chemical, petroleum, process, pipeline and related industries, National Airoil CHEMICAL-PETROLEUM up-firing burner units are achieving widespread field acceptance. And for good reason!

In accordance with our continuing policy of product improvement, the present design of this gas firing unit (now in actual quantity use) offers several time-and-money-saving "first time" features:

- An increased proportion of combustion air can be induced, partially independent of stack-furnace draft.
- Thorough mixing of the combustion air can be obtained with a minimum of O_2 in the stack gases. Result: high thermal efficiency; maximum radiation heat transfer.
- Capability exists for changing to different gases with some variation in specific gravities and calorific value to maintain approximately the same gas fuel pressures and heat release.
- Proper flame outline can be obtained relative to the furnace dimensions and proximity of tube surfaces.
- An absence of flash or burn back within the burner casting when firing hydrogen-rich gas.
- Regulation ease and capacity flexibility are assured.

National Airoil C. P. gas units can be supplied with a medium pressure gas pilot for electric ignition. A sufficient range of sizes is available to handle standard capacities. A similar National Airoil design also can be furnished for *oil only*, for *combination gas and oil*, or for *forced draft*.

Literature on these versatile C. P. burner units, together with technical and engineering data is available. Why not write for it *today* while you're thinking about it?

NATIONAL AIROIL BURNER

Established 1912
Incorporated 1917

NATIONAL AIROIL BURNER COMPANY, INC.

1284 E. Sedgley Avenue • Philadelphia 34, Pa., U.S.A.

Industrial Oil Burners, Gas Burners and Combustion Equipment

The gate was good . . .

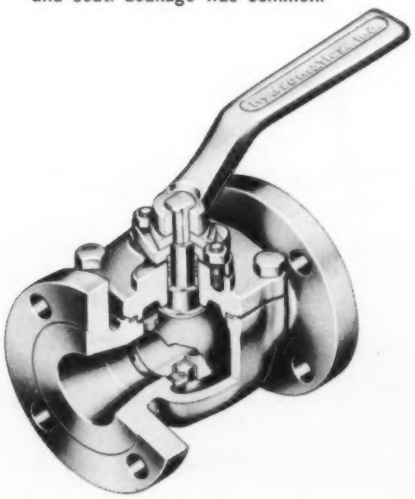
. . . *but* **FLO·BALL**® *is better!*

Flow capacity was always the gate's strong point. But, to go from open to closed required many, many turns of a screw. This screw suffered from wear, backlash and galling. You couldn't operate it quickly. To support the screw, valuable space was taken by bulky superstructure.

As sizes went up, the gate became extremely complex. Problems mounted. Tremendous locking forces sometimes warped the seats. The edge of the gate eroded whenever used for throttling. The sliding motion tended to score the seats. Dirt and solid particles in the line scored the wedge and seat. Leakage was common.

The Hydromatics **FLO·BALL** valve, unlike the gate, contains only one moving part — the ball. Supported top and bottom by frictionless teflon bearings, the ball turns smoothly, is always in contact with the seat. Tight sealing is a natural by-product of this design. So is maximum flow. Under normal service, the valve should last forever. No screws, no wedges, no chattering. On-off takes only a ¼ turn. Maintenance takes a holiday.

Try the **FLO·BALL** for on-off or throttling. You'll be glad you did!



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HYDROMATICS, Inc.
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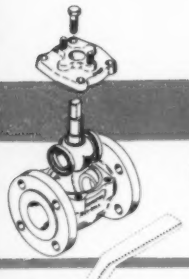
Compare FLO•BALL® feature for feature ... there is no equal!



	FLO-BALL	Ball Valve A	Ball Valve B	Ball Valve C	Ball Valve D	Ball Valve E	
1. TOP ENTRY All internal parts can be removed and re-installed without removing valve from line.	√			√			
2. TOP AND BOTTOM GUIDED BALL Provides truly double seal, extends seat life. Makes for easy operation.	√						
3. DOUBLE SEATS Interchangeable and replaceable seats insure sealing in both directions; give double protection against leakage.	√	√	√	√	√	√	
4. FLANGES INTEGRAL WITH BODY Rugged, one-piece body design gives greatest possible strength.	√	√		√			
5. ONE PIECE BALL AND STEM No possibility of separation of ball from stem. Always perfect alignment with zero backlash. Foolproofed for assembly.	√						
6. BLOCK AND BLEED Top and bottom guided ball and floating seats provide simultaneous up-stream and down-stream seal . . . a true block and bleed valve. Block and bleed type available on special order.	√						

Specify the FLO • BALL for your application

	SCREWED ENDS	FLANGED ENDS
Sizes	⅛" — 2"	1" — 36"
Pressures	Vacuum — 600# — 3000#	150# — 300# — 600# (ASA Rating)
Materials	Carbon Steel, Stainless Steels, Semi-Steel, Brass, Alloy 20, Monel	
Operators	Manual, Hydraulic and Motor	
Your Choice of FLO-BALL Types	Two-Way, Three-Way, Fire-safe, High Pressure (to 10,000 psi), Cryogenic, etc.	

Gentlemen:

I am interested in getting complete information on FLO-BALL valves.

My application is_____.

☐ *Send sales engineer* ☐ *Send literature*

Name_____ Title_____

Company_____

Street_____

City_____ State_____

1

FLO-BALL

Hydromatics, Inc.

BLOOMFIELD, NEW JERSEY

Fill in this card ... mail today!

Printed in U.S.A. ©1961

Rejection* Problem?

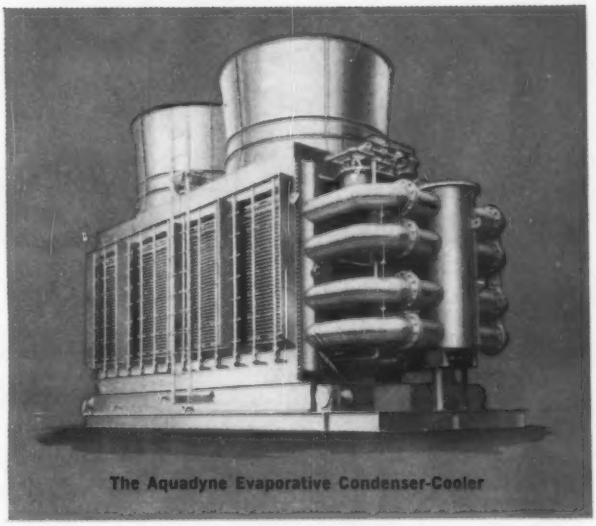
*No more problems (*Heat Rejection, that is) when you install the Aquadyne.*

Here is what the **Aquadyne** offers:

- A wetted surface — condenser — cooler for any pressure in any size.
- An engineering background of over a quarter century of heat transfer and vacuum experience.
- Uses practically no water and beats all other condenser-coolers of this type for close temperature approach.
- Combines the functions of a condenser–cooler–cooling tower all in one unit.
- Provides any desired heat rejection and solves your water problem.

Special Note: NOW is the time to do something about your cooling water problem.

Call in our nearest sales engineer and learn the details as applied to your needs.



The Aquadyne Evaporative Condenser-Cooler

Heliflow Corporation

GRAHAM MANUFACTURING CO., INC.

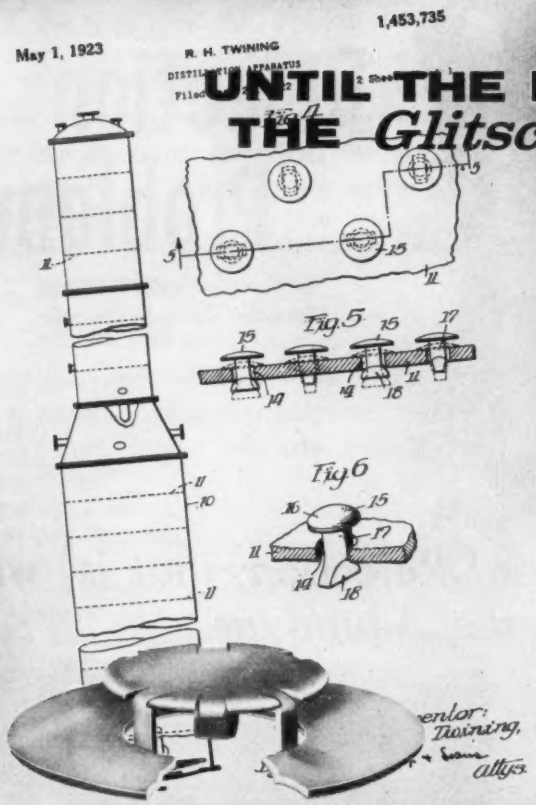
170 GREAT NECK ROAD · GREAT NECK, N. Y.

Factory: Batavia, New York
Other Graham-Heliflow precision-built products:
Heliflow Heat Exchangers, Steam Jet Ejectors, Monobolt Heat Exchangers,
Deaerating Heaters, Surface and Barometric Condensers,
Steam Vacuum Refrigeration, Panaflow Exchangers,

Albuquerque, N. Mex., Atlanta, Ga., Baltimore, Md., Boston, Mass., Buffalo, N. Y., Chicago, Ill., Cincinnati, O., Cleveland, O., Coral Gables, Fla., Denver, Colo., Detroit, Mich., Hato Rey, P. R., Honolulu, Hawaii, Houston, Tex., Kansas City, Mo., Los Angeles, Calif., Mexico, D.F., Mex., Minneapolis, Minn., Mobile, Ala., Philadelphia, Pa., Phoenix, Ariz., Pittsburgh, Pa., Richmond, Va., Roanoke, Va., San Francisco, Calif., Seattle, Wash., St. Louis, Mo., Toronto, Ont. Tulsa, Okla.,

Not since 1923

when an early patent was granted covering a valve type tray—has there been any significant change or improvement in this type of tray, other than physical shape and dimensions . . .



Glitsch V-1 Ballast Unit

UNTIL THE DEVELOPMENT OF THE *Glitsch* BALLAST TRAY

. . . a two-stage vapor discharge unit that is:

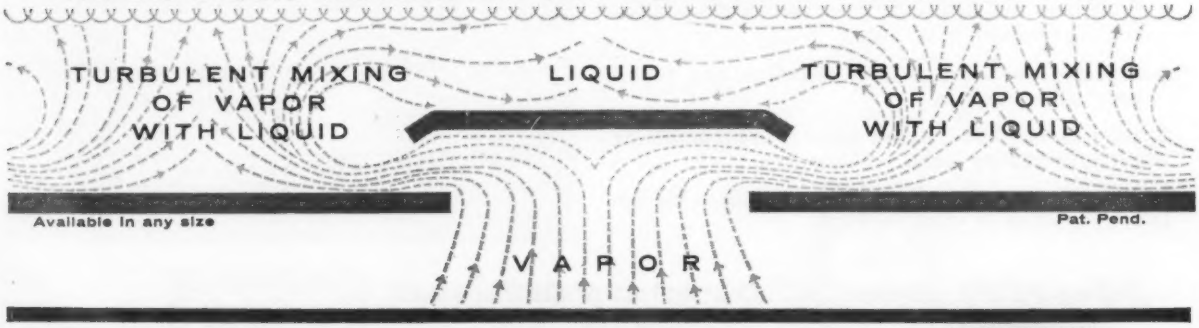
- ★ Low in cost
- ★ Low in maintenance
- ★ High in capacity
- ★ High in efficiency
- ★ High in turndown ratio

The Glitsch V-1 Ballast Unit has a single moving element with a two-stage action. The valve element positions itself initially for low to medium vapor rates and is then free to travel vertically to provide an increased orifice for very high vapor rates.

The high efficiency obtained by the Glitsch V-1 Ballast Tray is a result of the centripetal "fantail" mixing of the vapor and liquid. The vapor discharge orifice of the element is so shaped that the vena contracta at the vapor-liquid interface is amplified by the centripetal force of the vapor, resulting in extreme turbulence, greater interfacial area, and more thorough mixing of the vapor with the liquid.

For additional information on the V-1 Ballast Tray, ask your Glitsch representative for Bulletin #160. Offices in principal cities.

VAPOR-LIQUID ACTION OF THE GLITSCH V-1 BALLAST UNITS



Fritz W. Glitsch & Sons, Inc.

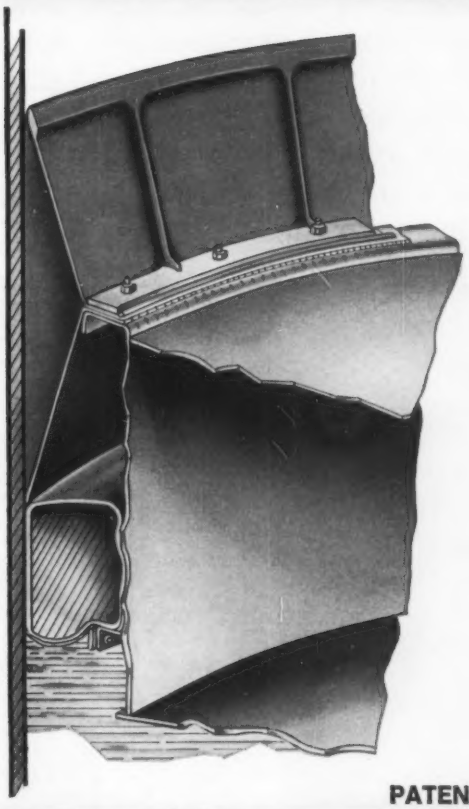
GENERAL OFFICES AND MANUFACTURING PLANT: 4900 Singleton Blvd. • P. O. Box 6227 • Dallas, Texas, U.S.A.
SUBSIDIARIES AND MANUFACTURING PLANTS: Fritz W. Glitsch & Sons (Canada) Ltd., Uxbridge, Ontario, Canada
Glitsch-Monterrey, S. A., Monterrey, N. L., Mexico.
SALES OFFICES: New York • Cleveland • Chicago • Tulsa • Houston • Los Angeles • Baton Rouge • Charleston, W. Va.

Glitsch "SINGLE ENGINEERING RESPONSIBILITY"

Manufacturers of Superior Fractionating Trays Since 1937

ALL FLOATING ROOF TANKS ARE FULLY EQUIPPED, **BUT...**

Only Tubeseal Has Lightning-Proof, Electro-Conductive Weather Shield



PATENTED

Tubeseal electro-conductive weather shields are an *exclusive tried and proved development.* They provide positive protection against lightning-caused rim fires. ■ How? By maintaining a *continuous* grounding bond between roof deck and shell—concentration of static charges is impossible. There has *never* been a lightning fire where any of the many hundreds of Tubeseal System Floating Roof Tanks are installed throughout the world—they're "lightning proof." ■ This is scientific and safe storage protection for the entire range of volatile products. Tubeseals can be installed on any of your tanks—new, old, riveted, or welded. You owe it to the future safety of your conservation facilities to investigate. Send for the Tubeseal Bulletin now—it could be important.

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Pittsburgh-Des Moines Steel Company

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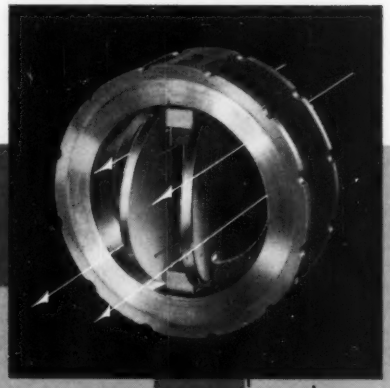
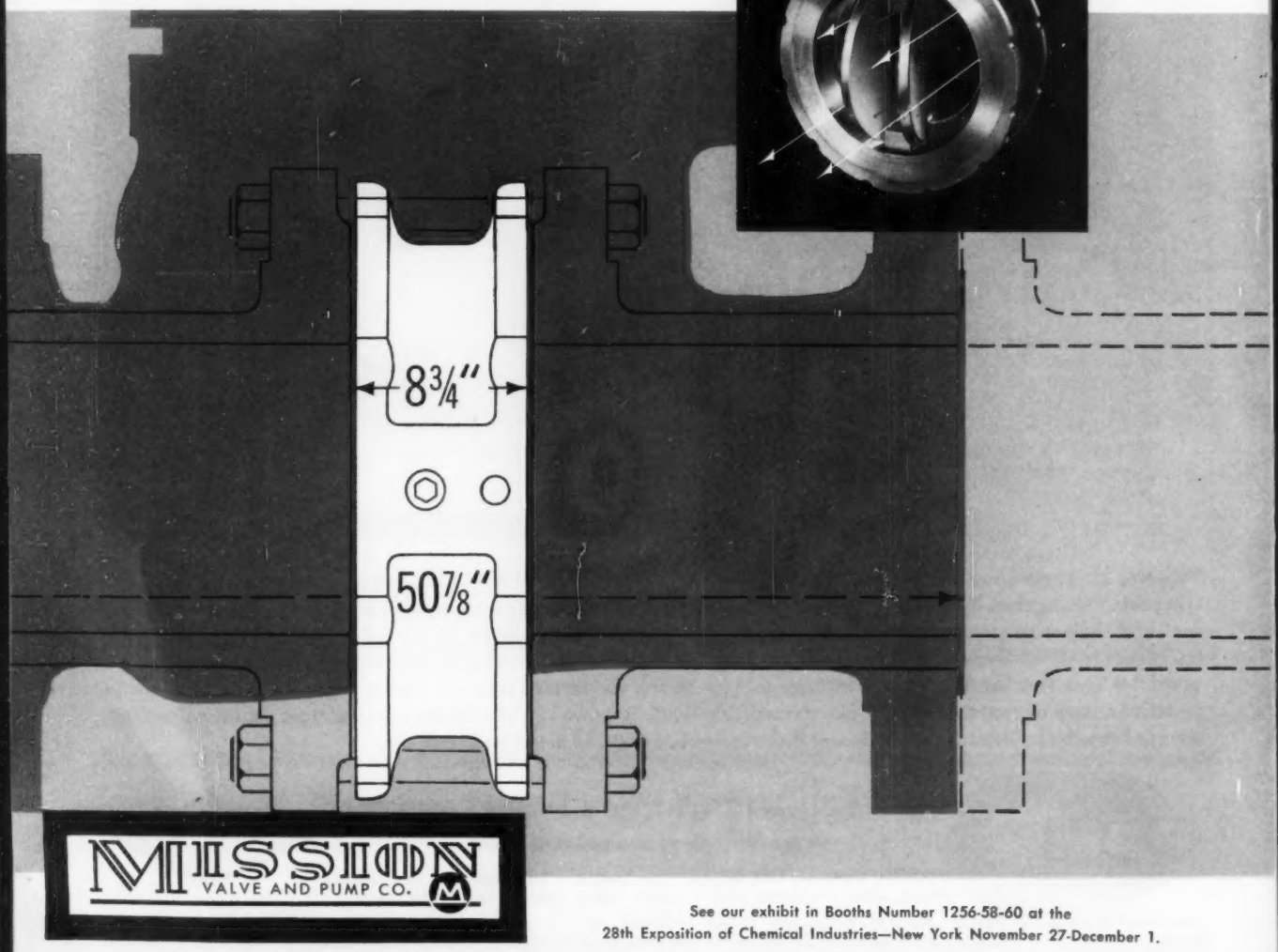
The illustration compares a 10-inch Duo-Chek Check Valve with a conventional check valve. In one application a 10-inch, Series 2500, Duo-Chek, which meets all ASA strength and design requirements except face-to-face size, is in continuous operation on a reciprocating compressor discharge line. A conventional swing check in this service would weigh over 5,000 pounds. The Duo-Chek weighs 285 pounds.

Here are some more quick facts: Available in sizes from 2 to 48 inches, ASA series 125 through 2500, in steel, stainless, aluminum, and bronze. Corrosion and heat resistant seals available. To find out more about these NO-Slam, easy-to-install, easy-to-maintain valves, write Mission today. Your competitors are already saving with them.

Mission Duo-Chek weighs less than 10% as much

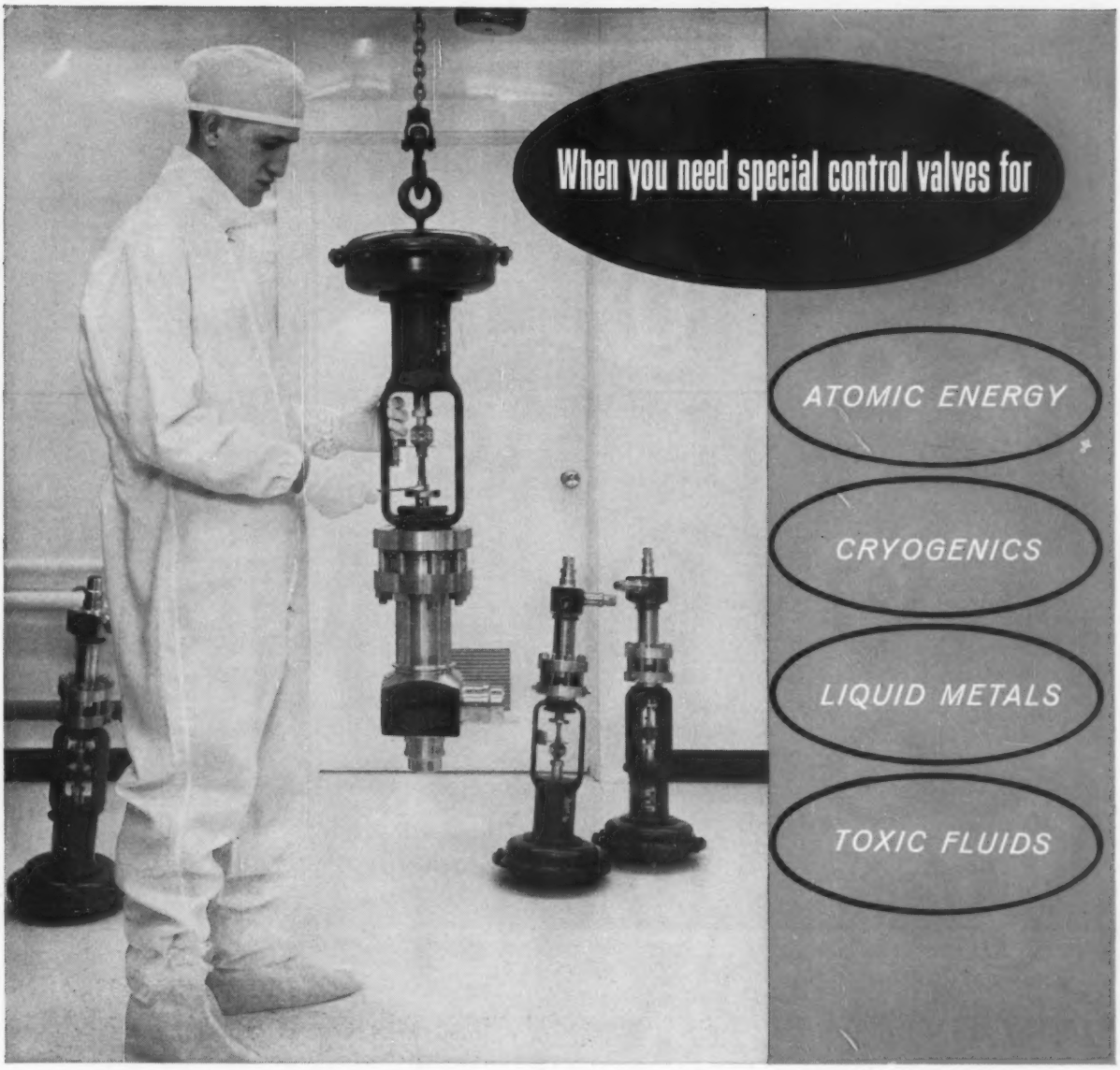




MISSION VALVE AND PUMP CO.

See our exhibit in Booths Number 1256-58-60 at the 28th Exposition of Chemical Industries—New York November 27-December 1.

MISSION VALVE AND PUMP CO. A SUBSIDIARY OF MISSION MANUFACTURING CO. P.O. Box 4209, Houston, Texas • Cable Address "MISSCO" Export Office: 30 Rockefeller Plaza, New York • In the United Kingdom: MISSION MANUFACTURING CO., LTD., 1 Hanover Square, London W. 1 England • Cable Address "MISSOMAN" • Sold by Mission Manufacturing Company outside of Canada and the U.S.A.



Fisher facilities and engineering skill are at your command

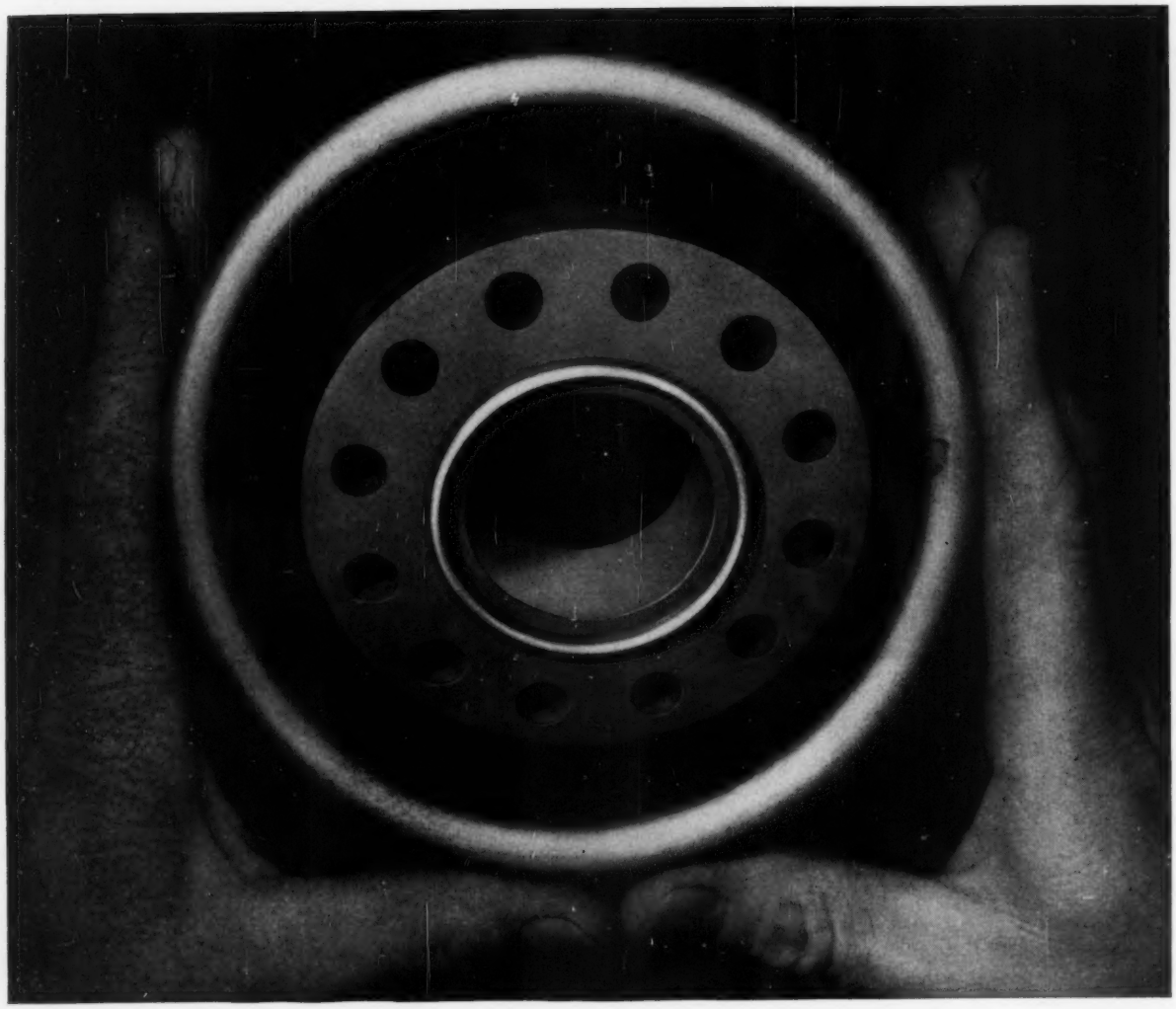
Typical of the special control valves assembled in the spotlessly clean Fisher white room is the Type SS-30, a high temperature angle body for controlling liquid metals at pressures up to 250 psi and temperatures of 1500° F. The SS-30 is also used in the atomic energy field and for control of toxic fluids in the chemical industry. Made of forged or bar stock material, the SS-30 has seal-welded joints, Stellite faced valve plug and seat, and bellows seal to prevent valve stem leakage. Stainless steel valve body is self-draining in both vertical and horizontal positions. SS-30 is tested by mass spectrometer when required to meet critical body and seat leakage rates.

Pressurized rooms, filtered air, pre-cleaned tools, and properly attired technicians will keep your equipment immaculate until capped and sealed for shipment. Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

For more data on advertised products, use cards, last page.



INSTALL J-M V-TITE® GASKETS

Right to start with...right to stay with

IF YOU ARE CONCERNED with the design or maintenance of ring-type joints, it will pay you to insist on the tighter, more efficient and longer-lasting seal you get with J-M's V-Tite design.

If it's your job to keep this equipment operating at top efficiency, here's a good point to remember: the gaskets that are right to *start* with . . . are right to *stay* with.

V-Tite Gaskets are "right" because every step in their manufacture is meticulously performed. Close tolerances are rigidly maintained for matching of rings with flange grooves. Carefully-controlled annealing keeps gasket hardness well below flange hardness . . . to assure proper flow and sealing without damaging the flange surfaces. Contact surfaces are smoothly finished . . . with no ridges, no tool or chatter marks that cause joint leakage.

J-M produces a wide selection of custom-designed and standard gaskets in any material, dimension or cross-section you require . . . including the new pressure-actuated BX Ring Gasket for extreme pressure service up to 15,000 psi at temperatures up to 250 F.

Complete information from your J-M Distributor. Or write to Johns-Manville, Box 359, New York 16, N.Y. In Canada: Port Credit, Ontario.

V-Tite Gaskets meet API specifications

JOHNS-MANVILLE

COPPUS BLUE RIBBON PRODUCTS

Coppus Steam Turbine with Built-In Speed Reducer

STAMINA — You can literally *see* stamina in every dimension of a Coppus Turbine . . . rugged reliability that assures you stable, positive performance. It truly "wins" the Blue Ribbon with which it is marked . . . through advanced design, top quality materials, and thorough testing. With Coppus you're always certain of Blue Ribbon features such as these —

A totally enclosed governor . . . totally enclosed, independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Sizes from 1 HP to 250 HP. All Coppus Products carry the same Blue Ribbon assurance of reliable performance. For further facts on turbines, send for new Catalog 200. COPPUS ENGINEERING CORPORATION, 421 Park Ave., Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES

HOW MUCH automation ... and WHEN?

BAILEY 700 SYSTEMS can help you make sure . . . with step-by-step benefits

Many important—and profitable—improvements in operations can be accomplished with analog and digital computer equipment.

Too much, too soon, however, can be costly—as can too little, too late. Intermediate stages of refinements in measurement and control are desirable and necessary. These not only can produce substantial benefits, but can demonstrate the additional improvements possible with further—or ultimately complete automation. Bailey step-by-step automation assures against loss of prior investment.

Bailey engineers can help you determine optimum usage of *Bailey 700 Analog and Digital Systems* in your operations. They are equipped, by broad experience, to provide single-source responsibility from sensing and measuring instrumentation to complete automation. *Bailey 700 Systems* are installed, in operation, or on order, at locations from coast to coast and throughout the world.

Find out what this Bailey experience can offer you. Contact your Bailey District Office.

SIX STEPS TO FULL AUTOMATION

Centralize and simplify information display—use analog and digital techniques to clarify information, aid operator understanding, improve reliability of interpretation, and save space.

Extend use of interlocks and limiting circuitry—use digital solid-state components to extend supervisory controls... minimize effects of human error.

Increase use of automatic sub-loops—simplify and standardize the starting, controlling, and stopping of major plant components and sub-systems.

Extend on-line controls—integrate sub-loops, interlocks, and limiting controls with conventional controls to secure automatic operation over full range, once unit is on the line.

Provide performance monitoring—add computing facilities to provide up-to-date calculations for operation improvement and maintenance scheduling.

Integrate all system elements—add start-stop control to provide full automation, the ultimate goal.

CP 159-1

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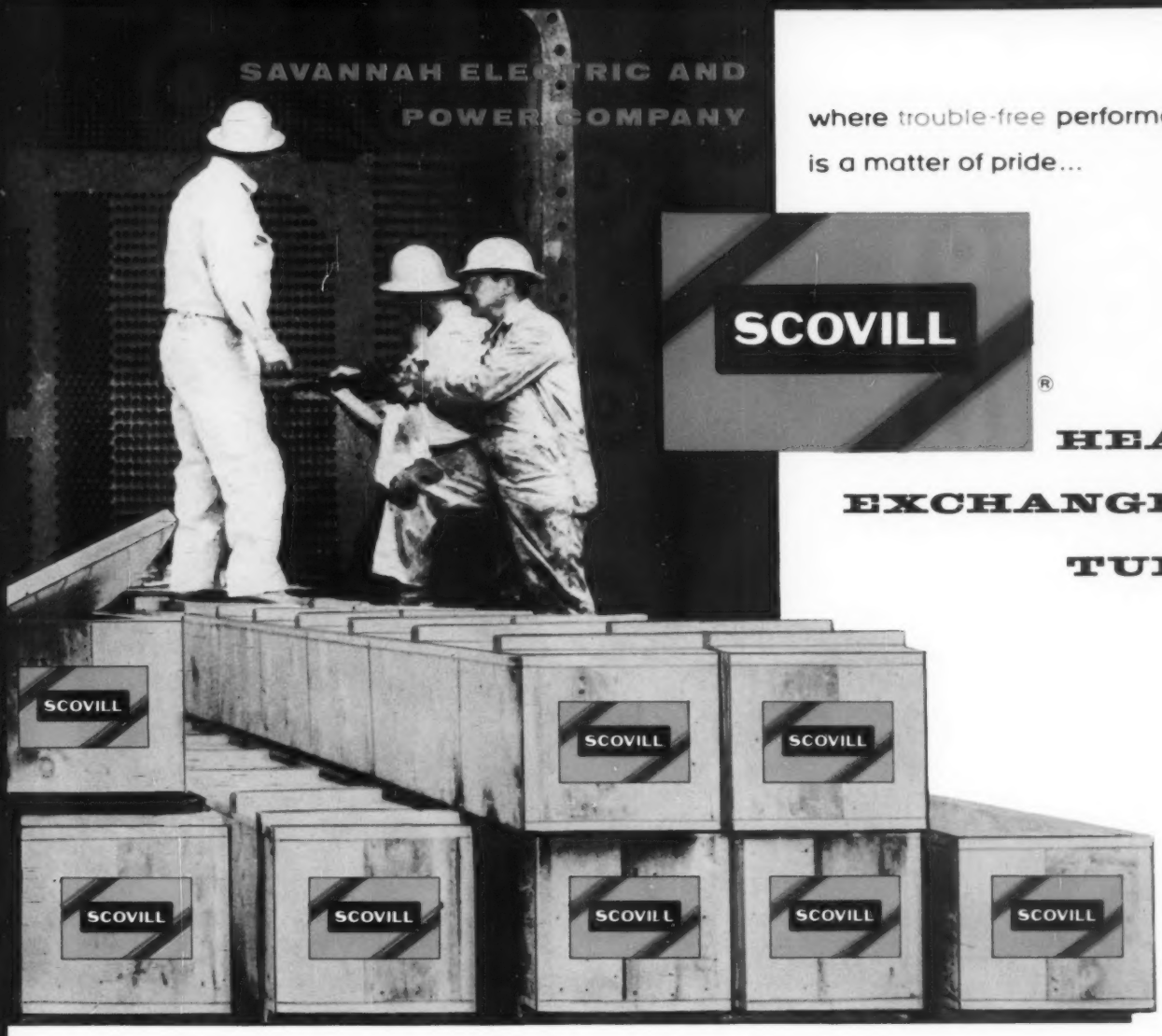

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Scovill Heat Exchanger Tubes enjoy a first-choice reputation among outstanding plant operators because of the excellence of Scovill tube alloys . . . their superior uniformity and their close adherence to all specifications through extremely tight quality controls maintained by our tube mills.

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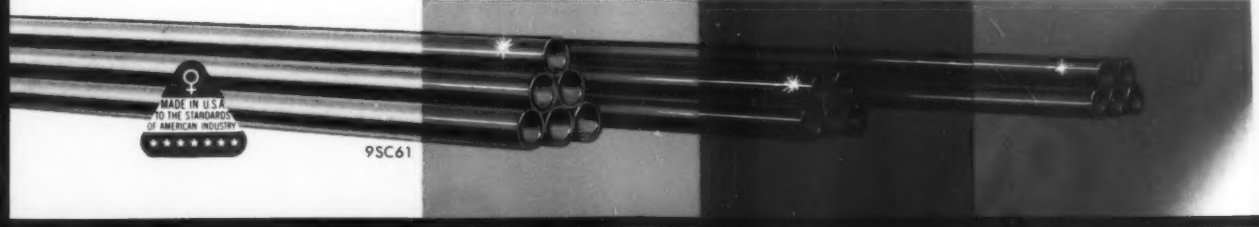

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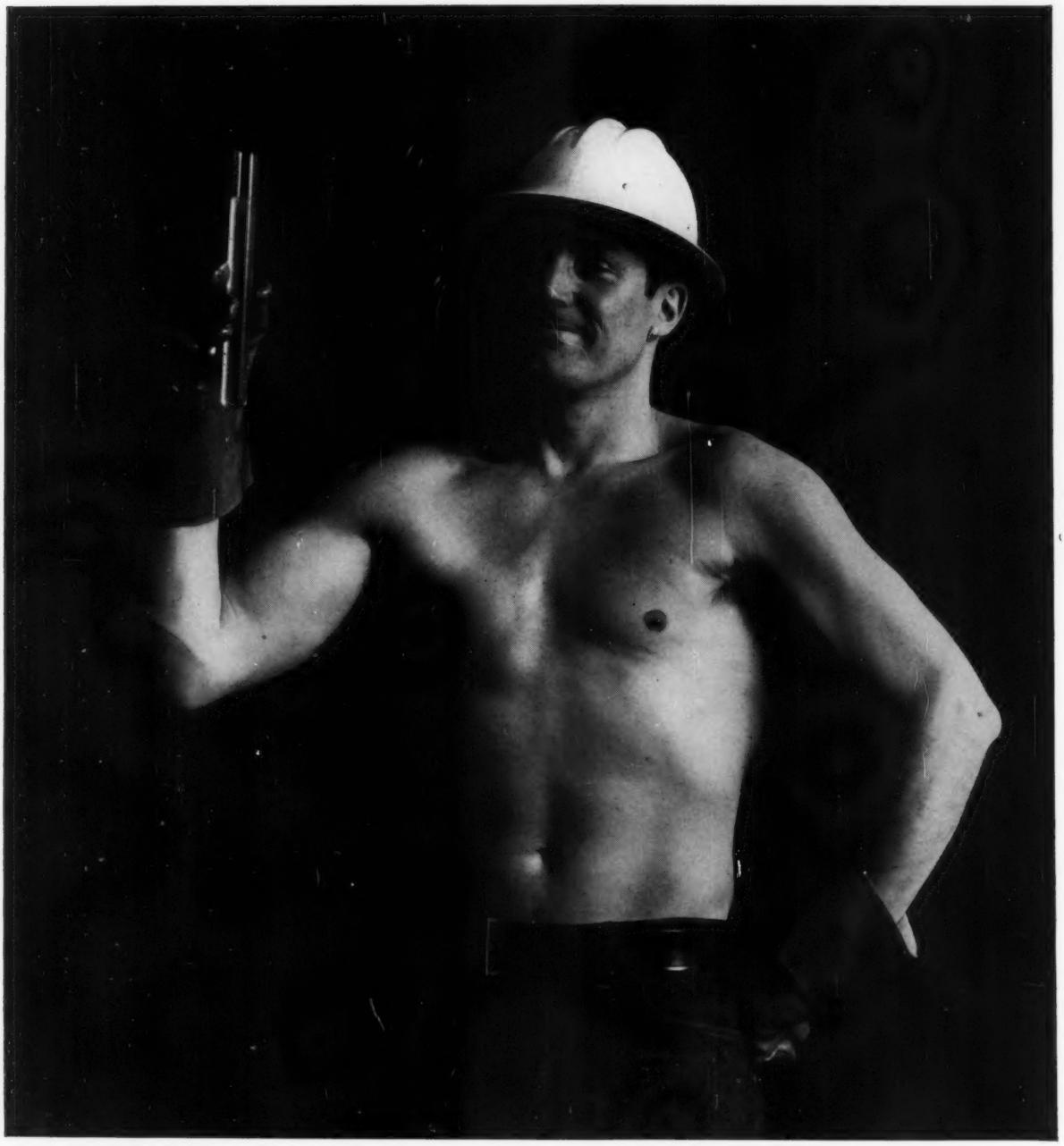

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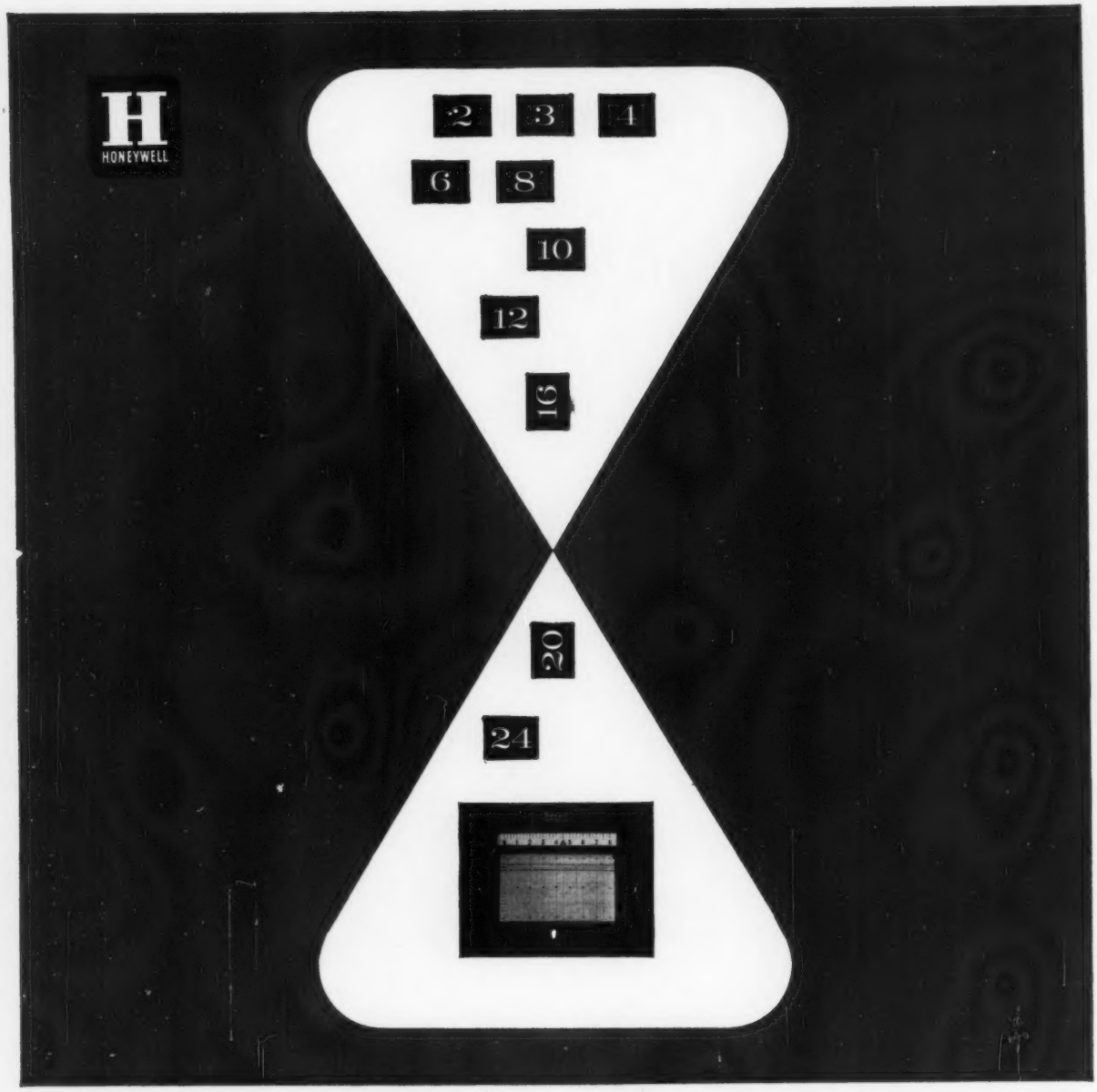

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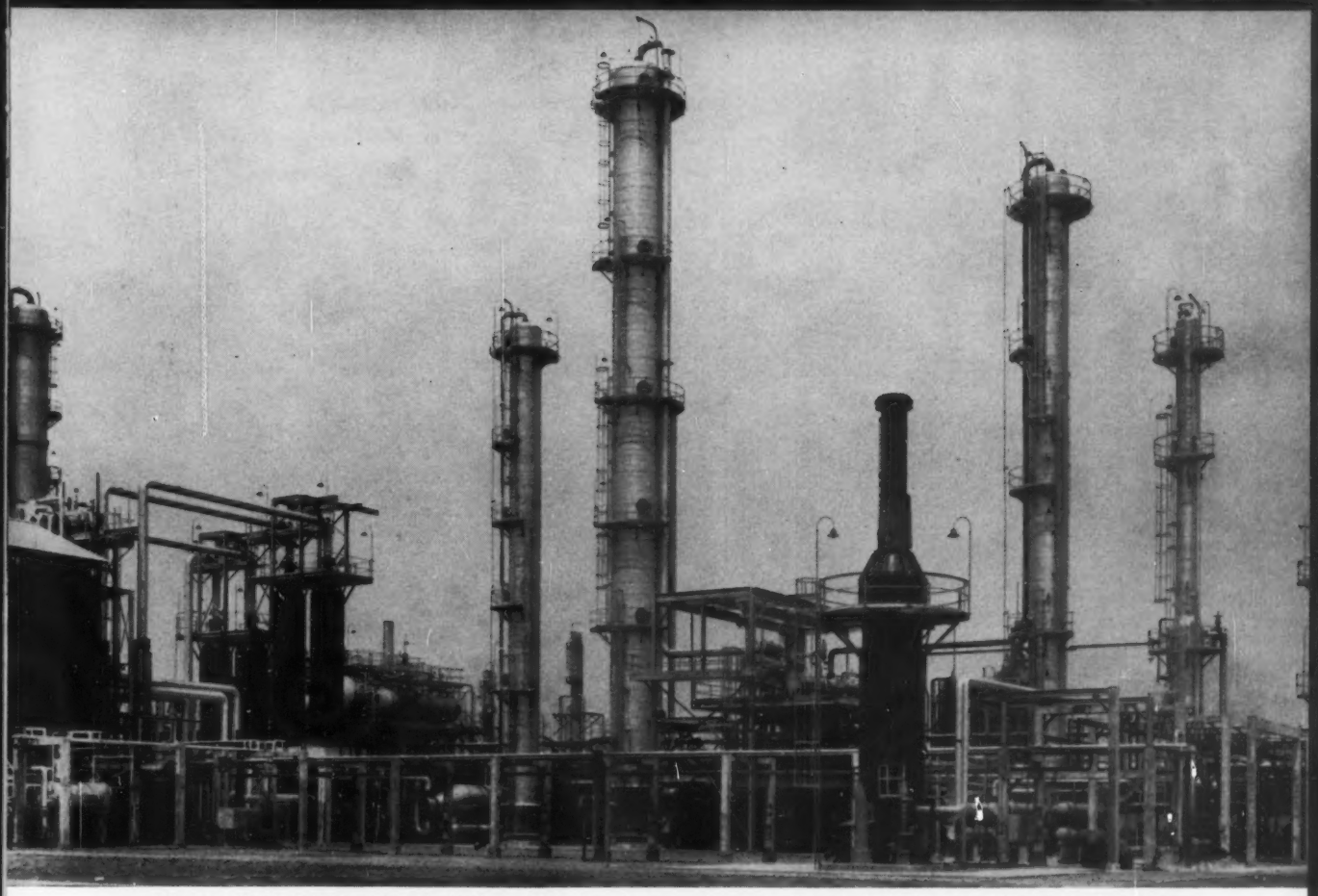

View of 16,000 BPSD PLATFORMING® unit at the Houston, Texas, Refinery of SHELL OIL COMPANY, licensed by UNIVERSAL OIL PRODUCTS COMPANY and designed in conjunction with Shell.

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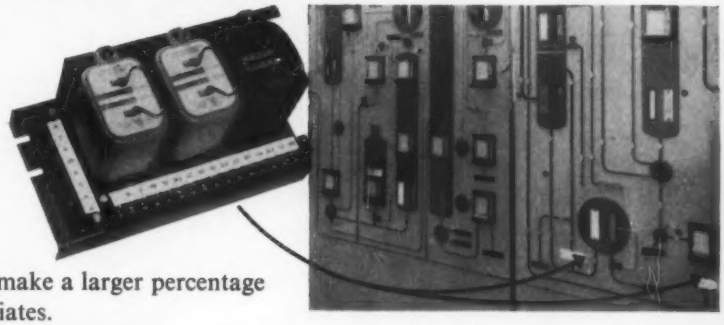

Panalarm Annunciators warn Platformer T.M. operators when undesirable conditions develop at critical points by illuminating appropriate translucent plates on this graphic control panel, only a portion of which is shown. When desired, a simultaneous audible signal also attracts attention.

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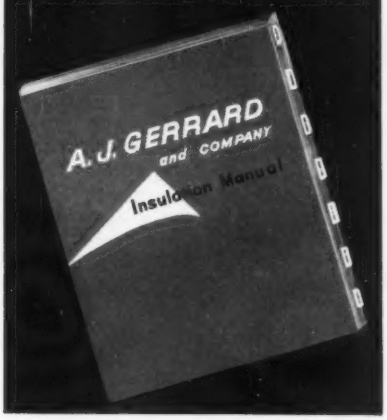

How do you know which is the right one? Consult the A. J. Gerrard Insulation Manual. It is available to qualified people who will write to us on their letterhead.

As a guide to specifying, it includes corrosion and technical data. It shows how other companies were able to properly insulate vessels, lines, vats, tanks, etc. And it covers the tools, materials and methods needed to strap insulation quickly, properly and economically.

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The Mail Box . . .

Too Many Words!

I have been a satisfied subscriber to the HP-PR since 1957 and have found many of the articles published during this period to be of considerable interest and usefulness.

I now find occasion to disagree with your editorial "A Common Denominator" June issue in connection with the system of information retrieval. The fundamental principles are good, the thesaurus may be excellent, but whoever decides the "key words" for the articles is "off the beam."

For example the article, "Processes and Prospects for Phenol" successfully summarizes what its title states yet you would wish your reader to classify it under 37 subheadings! I will file my copy under "petrochemical processes—phenol," knowing that I cannot get any information from it other than what the title states.

Examine the so-called key words:—

By-products—If I am interested in a by-product it will be by name only e.g. acetone and I have enough literature under this heading to inform me that it is a by-product of the cumene process of phenol.

Capacity—why? This only rings a bell when it refers to capacities of vessels.

Centrifuging, Distillation, Evaporators, Oxidation Chlorination Sulphoration, etc. Only brief reference to these unit operation and unit processes has been made in the article which certainly would not help me on a specific problem.

Caprolactam and all other chemicals—Only a chemist would find these references useful if he had forgotten all his basic chemistry. I am myself one such individual but I cannot foresee any immediate return to the noble art.

Catalyst, Economics, Equipment, Kettles, Pots, Reactors—This article would be completely misleading especially under the classification of "Pots" which I believe is no longer in current usage in this country.

I think you will see the point I am trying to make here; using the retrieval system with your key words is going to send somebody crazy reading through this article in order to get some background information on Evaporators, say, since I do not believe the word is mentioned more than once.

The system itself is good, the aim is good i.e., *quick* and *useful* reference. Please do not spoil it with over-elaboration which fundamentally is the very thing you are trying to avoid.

R. S. Williamson
Senior Chemical Engineer
Petro Engineering
Services, Ltd.

London

Seeks Abstracts

It is gratifying that the HP-PR is joining in the effort to standardize on "key words" as an aid to indexing, abstracting and information retrieval. It is to be hoped that these steps will lead to a system that can be manually handled by non-technical personnel with a great

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In addition to all of the calibration mixtures, Matheson supplies custom gas mixtures of every type, including radioactive gas mixtures. Extremely close tolerances on specifications can be held. Exact analysis of mixtures is available. Here are a few of the instruments for which calibration mixtures are offered:

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savings in engineers' time.

The choice of key words is not the same for every individual, but I find a greater use of verbs and consideration of a "key sentence" as the core of an abstract to aid in standardization, so that the result is most useful to many people. Can we expect a brief abstract soon for each HP-PR article?

R. H. Newton
Boston

EDITOR'S NOTE: *Probably not soon, but subject of course to the demand of readers.*

Likes Indexing But—

This is written in appreciation of your decision to adopt the key word indexing of articles in HYDROCARBON PROCESSING AND PETROLEUM REFINER. We have been using this method for some time now and look forward to the day when more technical journals will follow your lead. Because of the nature of information presented in your magazine, we clip, file and index many of the items.

One question arises however. *We had* believed from your May article on the subject and from the AIChE indexing that you would index with links and roles. The fact that our system and others use them, presents a problem, as we must still review your articles quite thoroughly to assign the proper roles. It is no problem for those people indexing without links and roles to omit them when they are given. But if they are used in a given index one must be consistent and always use them. The additional time required to complete the indexing of your articles where only the key words are given is a definite disadvantage. In our opinion, most indexers will use the complete system and we feel that your omission of the links and roles nullifies to a large extent the good accomplished by your selection of key words. No doubt you have reasons for choosing this partial indexing, but we trust you will reconsider your decision and provide complete indexing in future issues.

H. L. Johns
New Orleans

Editor's Note: *Your reasoning is quite correct; it would add to the system if links and roles were assigned. However, we find this refinement a difficult step at present for our indexers. As the system evolves, we will reconsider the additions of these two codes.*

Commends Valve Job

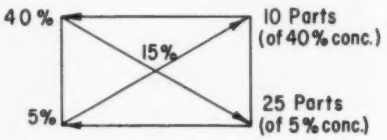
I wish to congratulate your Mr. Frank L. Evans, Jr., on the excellent job which he did on the Valve Special Report (October HP-PR. It is an excellent reference for future job evaluations.

I would like to have an extra copy of the report without having to tear up my October issue for inclusion in our standards book. Could you oblige?

F. Zapffe, chief engineer,
Foor Engineering Co.
Oklahoma City, Okla.

"Easier" Way

May I point out that "Simplified Calculations for Dilutions of Dispersions" in the How to Do It Department, June HP-PR, is easier to remember when drawn out in the following way (using the figures mentioned in Henry Merken example):



The desirable concentration is put at the center where the diagonals of a rectangle cross. At the left-hand corners, the concentrations of the two components are given. Then the differences along the diagonals give the parts to be taken of each component.

Dr. W. G. Schmidt
Clapham, Nr. Bedford
England

Asks Re Area

A recent article by Niemeyer, "Check These Points When Designing Knockout Drums," June, 1961, HP-PR, left much the same blank that most articles on this subject do. What *area* is to be used when calculating the diameter of a horizontal drum? Is it the x sectional area above the surface of the liquid or the area of the liquid interface? I have seen both presented but no good discussion to validate either one. A recent case I had required a holdup of 825 ft.^{3} for a 10-minute, ½-full surge. Sized on a vertical drum basis, this required a 5′ (diameter) vessel for entrainment and I believe a 17′ vertical drum would do with 11½′ liquid filled and 4′ between the liquid plus a mesh entrainment separator. If this vessel is horizontal, you cut the area in half with liquid holdup and hence require a larger diameter. I would like to see a discussion of this by the author with a treatment of the theory behind selection of an *area* for the horizontal drum when using the formula quoted on Page 155 in the article.

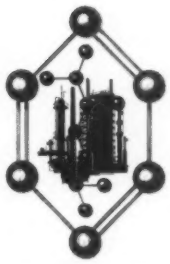
Ralph H. Cushing
Pittsburgh, Pa.

Wrong Location

Industrial Process Engineers, for whom Abe Devore, HP-PR author, is chief rating engineer, is located in Newark, N. J. and not Houston, Texas, as indicated in last month's Letters column.

Wanted:
YOUR Ideas . . .
The Editors invite letters from readers discussing timely topics pertinent to the HPI

THE 1961 PETROCHEMICAL HANDBOOK ISSUE



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The Demister, a versatile tool used to improve the performance of process equipment, has proven its efficiency and process cost savings in over 10,000 installations.

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Satisfactory for use with all process materials, the Teflon Demister is particularly useful with highly corrosive materials such as sulfuric, hydrochloric, and other mineral acids; formic, acetic, and other organic acids and acid chlorides; corrosive metal salt solutions, wet chlorine gas, hydrogen peroxide, etc.

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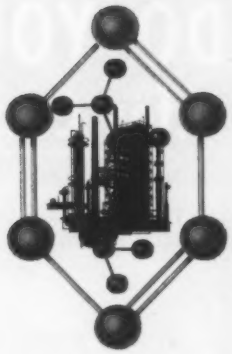

1961 Petrochemical Handbook Issue

PETROCHEMICALS are just as dynamic, attractive and meaningful today as when the word first appeared on our cover more than 19 years ago. And in 1942, petrochemicals were really just beginning. However, by 1950 they had really made their mark. Now it appears certain that this year—1961—will account for sales of almost $8 billion, that for production of about 55 billion pounds.

Apparently there's no limit in sight to this growth. Ten more years and petrochemicals should reach 150 billion pounds annually. As the over-all chemical industry continues to grow, petrochemicals will more than keep pace and account for more than half of the entire United States chemical production.

Interest Widens: Petrochemicals prove attractive because they are money makers. Large scale production of these basic intermediates and finished products means more chemicals and at lower cost. As the chemical industry integrates backward to raw material sources in petroleum, the refiner integrates forward into more finished chemicals. Presently only about $25 worth of chemicals are made from each barrel of crude petroleum processed. If demand and markets warranted, oil companies actually could convert right now about $300 worth of chemicals out of each $4 barrel of crude processed.

There's a big reason for wider oil company participation in petrochemicals. Profits from basic oil company products run about 4 percent whereas a profit of from 7-8 percent of sales is derived by those oil companies already in petrochemicals. And there's more to come. Each year about 500 new products come to market which trace their origin back to petroleum.

1961 Handbook: This year's handbook presents 102 processes. Along with the regulars you expect, there are many brand new, first-time-anywhere processes. Some of these newcomers are: Acetaldehyde from Ethylene, Isoprene from Propylene, Polycarbonates, Polyethylene (AGFO), Isotactic Polypropylene, Terephthalic Acid from Benzene, Trimethylolpropane, Urea (Lonza), Vinyl Acetate, Maleic Anhydride from Butenes and many others.

Bonus: Turn to Page 309 and you will see the first part of a 12-part series on hydrocarbon oxidation: "Combine Oxygen and Hydrocarbons for Profit" by Marshall Sittig. This is the most extensive survey of oxidation chemistry, as it applies to hydrocarbons, we have ever seen. It starts with an introduction to the chemical and economic fundamentals of hydrocarbon oxidation, with subsequent parts taking up such topics as making and handling oxygen, paraffin oxidation, autothermic cracking, aromatic oxidation and finally coal and coke oxidation. A look into the future of oxidation chemicals and processes will conclude the series.

Our industrial advisors for the 1961 Petrochemical Handbook Issue are shown above, left to right: O. V. Luke, Spencer Chemical Company; K. G. Carpenter, U. S. Industrial Chemicals Company; C. E. Rowe, Olin Mathieson Chemical Corporation; James R. Fair, Monsanto Chemical Company; Thomas C. Ponder, Petrochemicals Editor (standing); R. E. Lynn, B. F. Goodrich Chemical Company; W. E. Catterall, Esso Research & Engineering Company; Paul W. Cornell, Goodrich-Gulf Chemicals Incorporated; and John J. McKetta, The University of Texas.*

Petrochemicals Editor

* The attendance by executives, engineers, superintendents or other employes of petrochemical companies at these conferences does not constitute an endorsement of HYDROCARBON PROCESSING & PETROLEUM REFINER over any other publication. The fact that men of outstanding ability are allowed to attend these planning conferences shows the interest which companies have in sound editorial content for the benefit of the industry.

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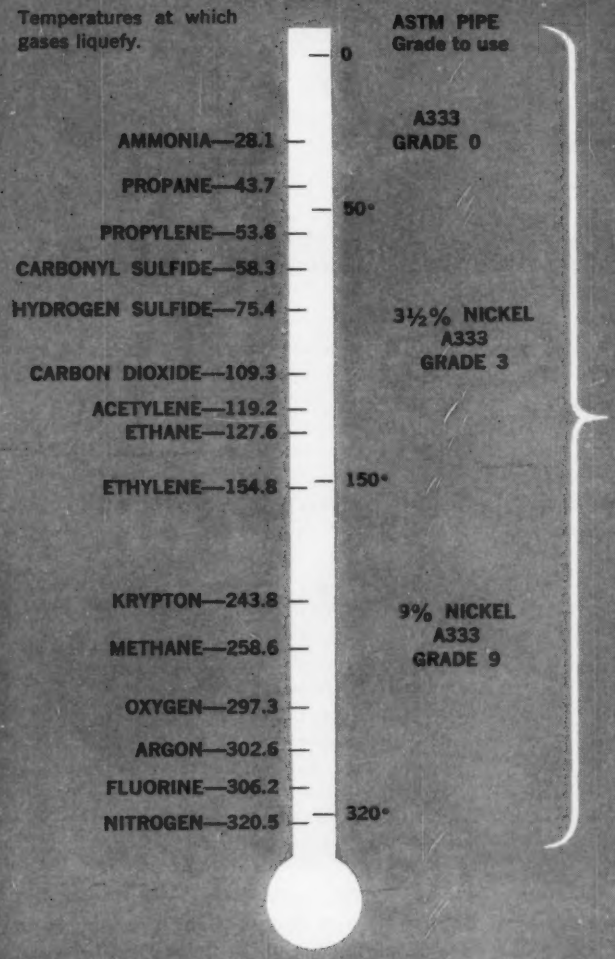

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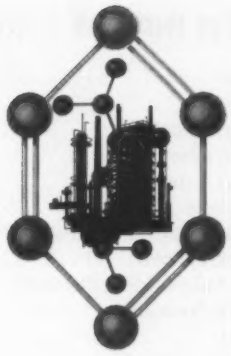
1961 PETROCHEMICAL HANDBOOK INDEXES



PROCESS INDEX

Acetaldehyde from Ethylene....206
Acetaldehyde....207
Acetone....249
Acetone....279
Acetophenone....279
Acethylene (BASF)....208
Acetylene and Ethylene....209
Acetylene....210
Acetylene (**SBA-Kellogg**)....211
Acetylene....212
Acetylene and Ethylene (**Eastman Process**)....213
Acrolein....249
Acrylonitrile....214
Acrylonitrile (**Knapsack**)....215
Alkar....216
Alkyl Aryl Sulfonates....217
Allyl Alcohol....249
Ammonia....218
Ammonia (**Claude Process**)....219
Ammonia....220
Ammonia....221
Ammonia....222
Ammonium Nitrate and Nitric Acid....223
Amyl Alcohol....224
Amyl Chloride....224
Aniline....225
Benzaldehyde....280
Benzene....236
Benzene....251
Benzene....298
Benzoic Acid....280
Benzyl Alcohol....280
Benzyl Benzoate....280
Bisphenol A....226
Butadiene from Butenes....227
Butadiene....235
Butenes....235
sec-Butyl Alcohol....268
Butylbenzene....277
iso-Butylene....283
Carbon Bisulfide....228
Carbon Black (**Oil Black**)....229
Carbon Tetrachloride (**Hoechst Process**)....232
Carbon Tetrachloride....230
Chloroform....230
Chloromethanes....230
Cumene....277
l-cyanobutadiene....214
Cyclohexane....233
Cyclohexane....234
Cyclohexane....256
Dehydrogenation....235
Detol....236
Diethanolamine....238
Dimethyalmine....267
Dimethyl Terephtahlate....296
Dinitrotoluene (**Meissner Process**)....237
Dodecylbenzene....217
Ethanol....239
Ethanolamines....238
Ethylbenzene....216
Ethylbenzene....277
Ethylbenzene....290
Ethyl Chloride....241
Ethylene....240
Ethylene and Propylene....242
Ethylene....243
Ethylene....209
Ethylene....213
Ethylene Carbonate....244
Ethylene Oxide....245
Ethylene Oxide and Glycol....246
Ethylene Oxide....247
Ethyl Mercaptan....247
Ethylthioethanol....247
Formaldehyde....248
Glycerol (**Acrolein and Hydrogen Peroxide**)..249
Hexamethylene Tetramine....250
Hexamine....250
Hydeal....251
Hydrodealkylation....252
Hydrogen Cyanide (**Andrussow Process**)....253
Hydrogen Cyanide....254
Hydrogen Peroxide....255
Hydrar....256
Hydrazine....273
Isoamylene (**Sinclair Process**)....257
Isoprene....258

PROCESS INDEXES Cont'd.

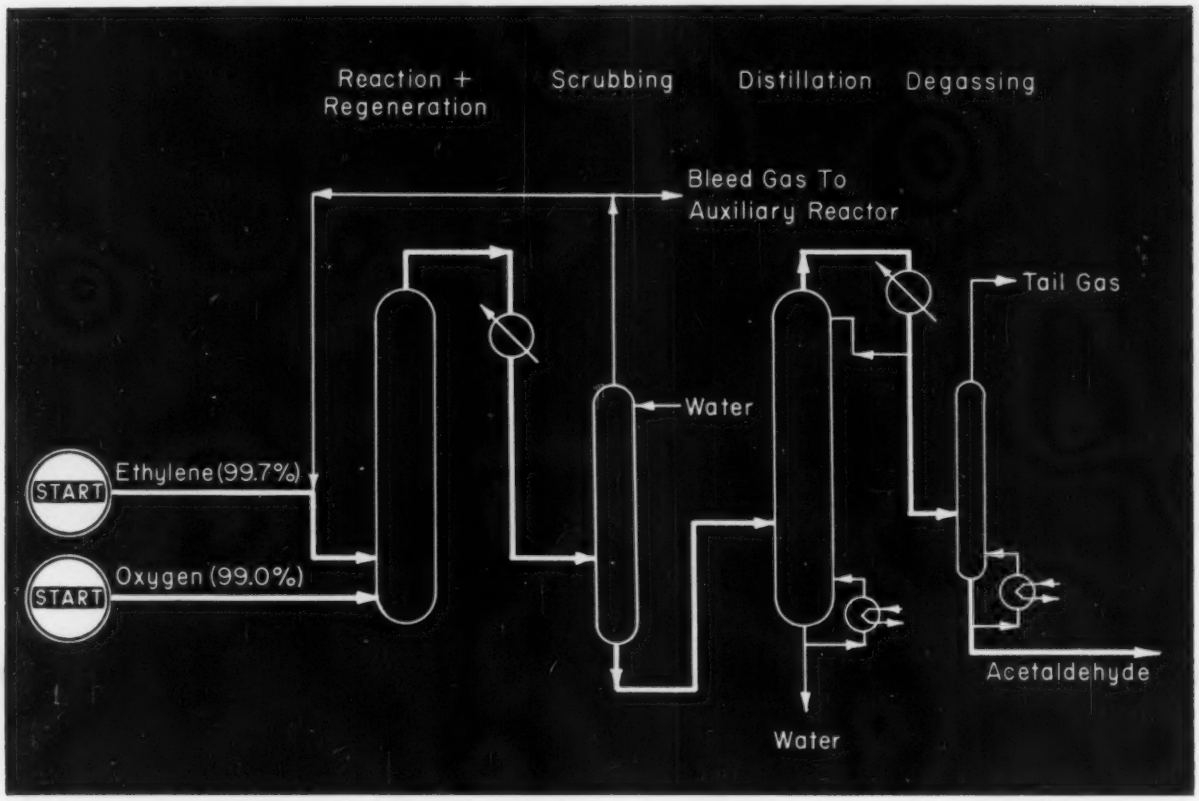
Isoprene 235
Isoprene 259
Isopropyl Alcohol 260
di-isopropylbenzene 277
Isopropyl ether 260
Lactronitrile 215
Low Temperature Hydrogenation (Bayer Process) 261
Maleic Anhydride (Butenes) 262
Maleic Anhydride 263
Methanol 264
Methanol (UHDE) 265
Methanol 266
Methylamines 267
Methyl Chloride 230
Methylene Chloride 230
Methyl Ethyl Ketone and sec-Butyl Alcohol (Maruzen Process) 268
Methyl and Ethyle Acrylate Monomer 269
Methyl Ethyl Pyridine 270
Methyl Mercaptan 271
Methyl Methacrylate Monomer 272
Methylstyrene 279
Monoethanolamine 238
Monomethylamines 267
Monomethyl Hydrazine 273
Mono Vinyl Acetylene 214
Naphthalene 236
Naphthalene 251
Naphthalene 301
Nickel Carbonyl 274
Nitric Acid 223
Nitroparaffins 275
Octafining 276
Olefin-Aromatic Alkylation 277
Oxo Process (Ruhrchemie AG) 278
Pentamer 277
Pentenes 235
Perchloroethylene 299
Phenol 251

CONTRIBUTORS INDEX

Aldehyd G.m.b.H.
Acetaldehyde from Ethylene 206
American Cyanamid Company
Acrylonitrile 214
Aniline 225
Amoco Chemicals Corporation
Methyl Mercaptan 271
The Atlantic Refining Company
Octafining 276
Becco Chemical Division, FMC Corp.
Hydrogen Peroxide 255
Bergbau-Forschung
Terephthalic Acid 296
California Research Corporation
Phthalic Anhydride 281
Celanese Corporation of America
Trimethylolpropane 300
Vinyl Acetate 308
Chemical Construction Corporation
Acetylene (BASF) 208
Ammonia 218
Methanol 264
Urea 302
Chemical & Industrial Corporation
Ammonium Nitrate and Nitric Acid 223
The Clayton Aniline Company
Sulfur Recovery (Stretford Process) 292
Continental Carbon Company
Carbon Black (Oil Black) 229
Continental Oil Company
Alkyl Aryl Sulfonates 217
Cosden Petroleum Corporation
Polybutene 283
Styrene 290
Detrex Chemical Industries
Trichloroethylene 299
Dutch State Mines
Urea 303
Esso Research and Engineering Co.
Butadiene from Butenes 227
Farbwerke Hoechst AG
Acetylene and Ethylene 209
Foster Wheeler Corporation
Ammonia 220
Urea 304
The Fluor Corporation, Ltd.
Ammonia 219
Synthesis Gas from Fuel Oil 293
General Electric Company
Polycarbonates 284
Girdler Corporation
Dinitrotoluene 237
Hydrogen Cyanide (Andrussow Process) 250
The Goodyear Tire & Rubber Company
Isoprene 258
Gulf Research and Development Company
Thermal Hydrodealkylation (THD) 298
Henkel & CIE
Terephthalic Acid 297
Hoechst-UHDE Corporation
Acrylonitrile (Knapsack) 215
Carbon Tetrachloride 232
Oxo Process (Ruhrchemie AG) 278
Houdry Process Corporation
Dehydrogenation 235
Detol 236
Hydrocarbon Research, Inc.
Acetylene 210
Hydrodealkylation 252
Institut Francais du Petrole
Cyclohexane 233
Isoprene 259

Phenol from Cumene 279
Phenol from Toluene 280
Phthalic Anhydride 281
Phthalic Anhydride 282
Polybutene 283
Polycarbonates 284
Polyethylene (AGFO) 285
Polyethylene (High Pressure—ICI) 286
Polyethylene (Low Pressure—Slurry-Solution Processs) 287
Polyethylene and Polypropylene (Low Pressure-Ziegler) 288
Polypropylene 289
Polypropylene 288
Propylene 235
Propylene 242
Propylene Carbonate 244
Propylene Tetramer 277
Propylene Trimer 277
Styrene 290
Sulfur Recovery (Haines Process) 291
Sulfur Recovery (Stretford Process) 292
Synthesis Gas (Fuel Oil) 293
Synthesis Gas 294
Synthol Process 295
Terephthalic Acid 296
Terephthalic Acid 297
Tetrachloroethane 299
Thermal Hydrodealkylation (THD) 298
Trichloroethane 299
Trichloroethylene 299
Triethanolamine 238
Trimethylamine 267
Trimethylolpropane 300
Unidak 301
Urea 302
Urea (DSM) 303
Urea 304
Urea (Lummus-Lonza) 305
Urea 306
Urea 307
Vinyl Acetate 308

Jefferson Chemical Company
Ethylene Carbonate 244
The M. W. Kellogg Company
Acetylene (SBA) 211
Ammonia 221
Ethylene 240
Synthol Process 295
Krell & Associates
Cyclohexane 234
Sulfur Recovery (Haines Process) 291
The Leonard Process Company
Hexamine 250
Methylamines 267
The Lummus Company
Ethylene and Propylene 242
Urea (Lonza) 305
Lurgi Corporation
Low Temperature Hydrogenation (Bayer Process) 261
Arthur G. McKee & Company
Methanol (Uhde) 265
Monsanto Chemical Company
Urea 306
Montecatini
Acetaldehyde 207
Acetylene 212
Ammonia 222
Chloromethanes 230
Formaldehyde 248
Hydrogen Cyanide 254
Methanol 266
Polypropylene 289
Urea 307
Olin Mathieson Corporation
Monomethyl Hydrazine 273
Pennsalt Chemicals Corporation
Amyl Alcohol 224
Petrocarbon Developments, Ltd.
Methyl Ethyl Pyridine 270
Rohm & Haas Company
Methyl and Ethyl Acrylate 269
Methyl Methacrylate 272
Nickel Carbonyl 274
Scientific Design Company, Inc.
Ethylene Oxide 245
Isoprene 258
Methyl Ethyl Ketone and sec-Butyl Alcohol (Maruzen Process) 268
Phthalic Anhydride 282
Polyethylene (AGFO) 285
Shell Development Company
Ethanol 239
Ethyl Chloride 241
Synthesis Gas 87
Stone & Webster Engineering Corp.
Acetylene and Ethylene (Eastman Process) 213
Ethylene 243
Isopropyl Alcohol 260
Stratford Engineering Corporation
Isoamylene (Sinclair Process) 257
C. M. Thacker
Carbon Bisulfide 228
Union Oil Compaany
Ethylthioethanol 247
Unidak 301
Universal Oil Products Company
Alkar 216
Hydeal 251
Hydrar 256
Olefin-Aromatic Alkylation 277



Acetaldehyde from Ethylene — ALDEHYD G.m.b.h.

Application: A process for acetaldehyde production by direct oxidation of ethylene. There are two variations of the process, one using oxygen and the other using air. The choice depends on local conditions such as oxygen cost, utility prices, and ethylene purity.

Description. The process employs a catalytic solution of copper chloride containing small quantities of palladium chloride. The reactions may be summarized as follows:

$$C_2H_4 + 2\ CuCl_2 + H_2O \xrightarrow{PdCl_2} CH_3CHO + 2\ HCl + 2\ CuCl$$

$$2\ CuCl + 2\ HCl + \tfrac{1}{2}O_2 \longrightarrow 2\ CuCl_2 + H_2O$$

In the reaction, palladium chloride is reduced to elemental palladium and HCl, and is reoxidized by cupric chloride. During catalyst regeneration the cuprous chloride is reoxidized with oxygen. The reaction and regeneration steps can be conducted separately or together.

Single-Stage Oxidation with Oxygen: Feed ethylene, oxygen, and recycle gas are directed to a vertical reactor and are contacted with the catalyst solution under slight pressure. The water evaporated during the reaction absorbs the exothermic heat evolved, and make-up water is fed as necessary to maintain the catalytic solution concentration.

The reacted gases are water-scrubbed and the resulting acetaldehyde solution is fed to a distillation column. The tail gas from the scrubber is recycled to the reactor. Inerts are eliminated from the recycle gas in a bleed-stream which flows to an auxiliary reactor for additional ethylene conversion.

Two-Stage Oxidation with Air: In this variation of the process, spent catalyst is reoxidized with air in a separate regenerator. Ethylene is converted to acetaldehyde in a single-pass contact with the catalyst solution at a slightly higher pressure than used in the single-stage unit. In a separator following the reactor, the pressure is released and reaction heat vaporizes the acetaldehyde product from the catalyst solution. The spent catalyst from the separator is pumped to the regenerator where it is reoxidized by contact with air. The two-stage unit can be operated with oxygen, and can process an ethylene-rich stream instead of pure ethylene.

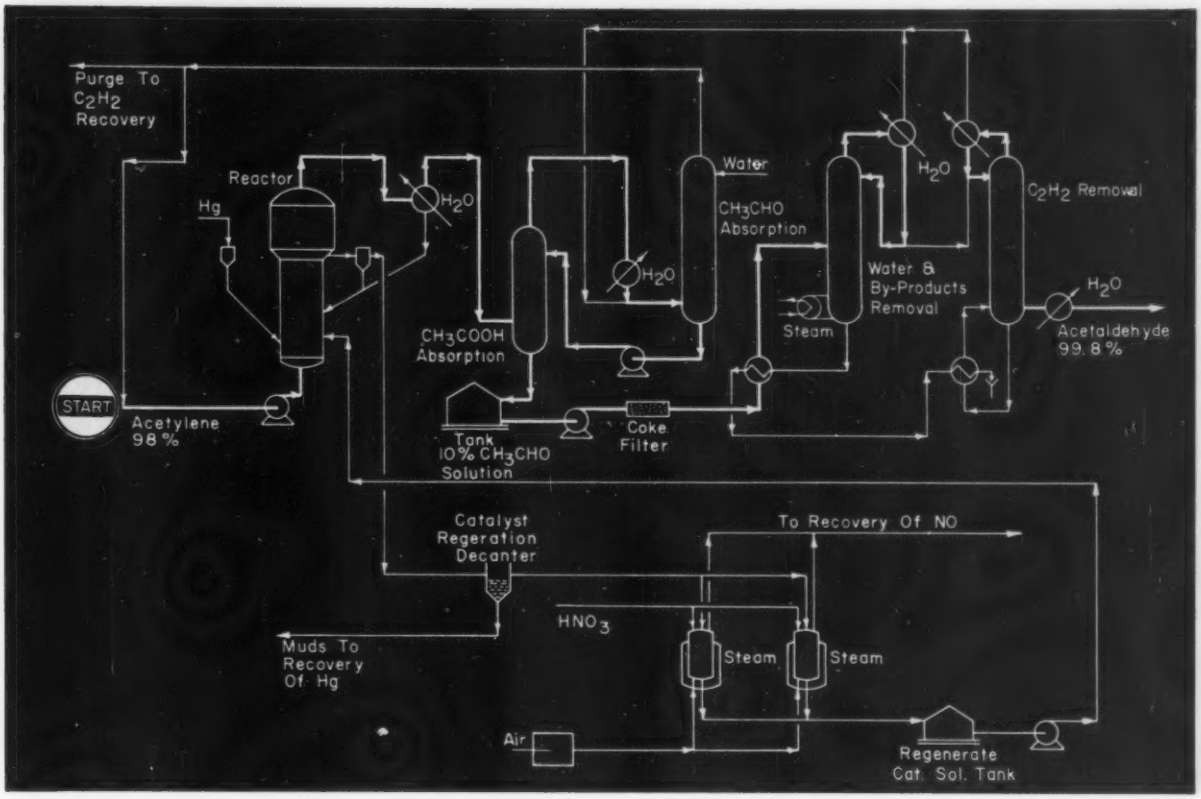
Raw Materials, Utilities, Personnel Requirements

	Per Ton Acetaldehyde Single-Stage	Two-Stage
Raw Material		
Ethylene (85-170 psig, 99.7% pure)	1,340 lb	1,340 lb
Oxygen (85 psig, 99% pure)	9,280 scf	—
Hydrochloric acid and catalyst	$1.40	$2.80
Utilities		
Cooling water	72,000 gal	48,000 gal
Well water	—	3,600 gal
Demineralized water	720 gal	48 gal
Steam (185 psig)	2,600 lb	600 lb
Steam (50 psig)	600 lb	1,800 lb
Electric power	190 Kwh	336 Kwh
Personnel		
Supervision	One supervisor and one foreman, either process.	
Manhours		
For 16,500 tons/year	0.192	0.192
For 33,000 tons/year	0.096	0.096
For 66,000 tons/year	0.048	0.048

Yield: In either process, an acetaldehyde yield of approximately 95 percent is obtained. By-product formation is negligible.

Commercial Development: In addition to the existing units of Farbwerke Hoechst AG and Wacker Chemie GmbH in Germany, plants will be built by Rhone-Poulenc (France), Societa Edison (Italy), and Pemex (Mexico). In the United States, Celanese Corporation will install a plant at Bay City, Texas. A number of plants are to be installed in Japan.

References: Further information is available from Hoechst-Uhde Corporation, Empire State Building, Suite 8204, New York 1, N. Y.



Acetaldehyde—MONTECATINI

Application: A process for manufacturing acetaldehyde by means of catalytic hydration of acetylene

Charge: Acetylene, 98 percent pure.

Product: Acetaldehyde having a purity of 99.8 percent.

Description: Acetaldehyde is obtained by direct hydration of acetylene, according to the following equation:

$$CH \equiv CH + H_2O \rightarrow CH_3 \cdot CHO$$

This reaction, catalyzed by mercuric ion, takes place by injecting gaseous acetylene into a mercuric sulphate solution, acidified by H_2SO_4.

During the process, owing to secondary reactions, a progressive reduction of mercuric ions, which are catalitically active, takes place to metallic mercury which is catalitically inactive.

In order to prevent the reduction of mercuric salts to metallic mercury, ferric sulphate is continuously added to the catalyst solution; the ferric compound is reduced to ferrous sulphate during the process.

The catalyst therefore must be continuously replaced for re-oxidization of ferrous sulphate to ferric sulphate.

To this aim the catalyst solution is continuously withdrawn and sent to the regenerator, after removal of mercury-containing muds; said muds are periodically hot-treated in order to recover metallic Hg. Regeneration of catalyst solution comprises a hot-treatment with nitric acid in the presence of an air stream blown in the solution.

Nitrogen oxide is produced; ferrous ion is oxidized to ferric ion.

The regenerated catalyst is recycled to the acetylene hydration reactor. The latter operates adiabatically and the residence time of acetaldehyde in the catalytic solution is calculated in such a way to minimize side-reactions.

Acetaldehyde vapors, mixed with steam and unreacted acetylene overflow from the top of the reactor. The effluent mixture is then first cooled to about 60 °C; the condensate consists almost entirely of water which is sent back to the reactor. The gaseous mixture is then admitted into a column in which acetic acid is absorbed by the acetaldehyde solution flowing from the bottom of the successive acetaldehyde absorption tower. The gaseous mixture is further cooled, after the acetic acid absorption step, to about 30 °C in a final cooler.

From here the gas is sent to the absorption tower in which acetaldehyde is recovered as a crude aqueous solution.

Unreacted acetylene, together with inert gas contained in the starting gas feed flows from top of absorption tower and is sent back to reactor, while a small portion of it is continuously purged.

The purged gases, still containing acetylene, are sent to acetylene recovery which can be carried out by conventional means: in case the acetaldehyde unit is coupled to a methane cracking unit for the production of acetylene, the purged gases are sent to the main raw acetylene gasholder; thus they follow the concentration process of the pure acetylene production unit.

From the bottom of the absorption tower an acetaldehyde aqueous solution of 10 percent strength is obtained; this is sent first to the acetic acid absorption tower and then to mercury settling tanks.

Crude acetaldehyde solution is pumped, through a coke filter for separation of residual mercury and a pre-heater, to the distillation tower.

The distilled acetaldehyde is then purified from acetylene by a heating step in an acetylene stripping tower.

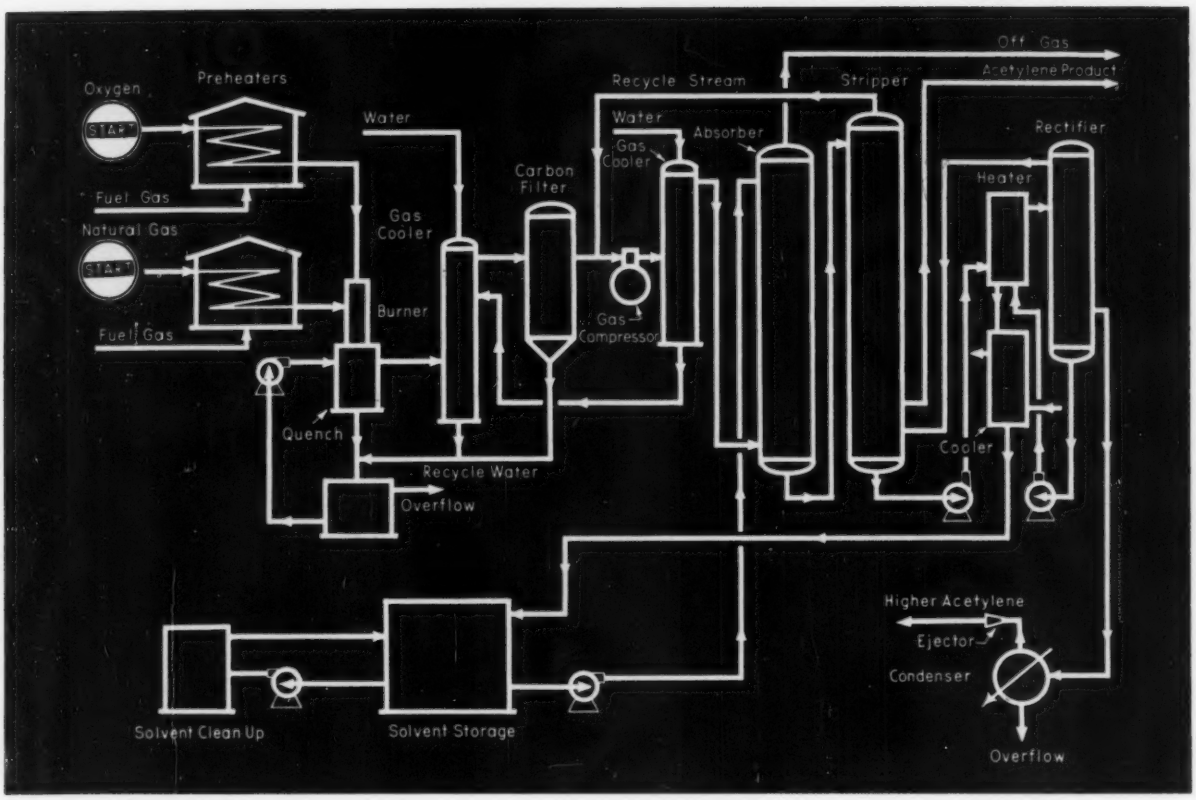
The final product has an acetaldehyde content of 99.8 percent.

Uncondensed gases flowing from the top of the acetaldehyde distillation tower are mixed with acetaldehyde vapors and acetylene leaving the top of the acetylene stripping tower and are recycled to the bottom of the column in which acetaldehyde vapors are first absorbed in water. From the bottom of the distillation tower a mixture of water and by-products is continuously drained off.

Operating conditions: The reactor operates at a temperature of about 85 °C. and the plant is run substantially at gasometric pressure.

Yields: Total yield of acetaldehyde is 95 percent based on acetylene consumption.

Commercial installations: A large industrial plant is in operation at the Montecatini Works in Novara, Italy.



Acetylene (BASF)—CHEMICAL CONSTRUCTION CORPORATION

Application: A process for making acetylene.

Charge: Natural gas; oxygen, 90-98 percent purity.

Product: Acetylene of 99+ percent purity.

Description: Oxygen and nautral gas are preheated in direct-fired heaters to about 1,200° F. The charge gases are mixed in a molar ratio of 0.60:1.00 oxygen:methane upon being fed to the converter. The converter is a vertical cylindrical unit comprising three sections: mixing chamber, flame room, and quench chamber. The mixing chamber is specially designed to provide rapid yet thorough mixing of oxygen and methane.

The mixed gases are fed to the flame room through a plurality of ports in a burner block designed to prevent backtravel or blowoff. In the flame, methane is cracked according to the endothermic reaction:

$$2CH_4 \rightarrow C_2H_2 + 3H_2$$

The combustion of methane supplies sensible and cracking heats. About one-third of the entering methane is cracked; most of the remainder is burned. Over-all conversion of methane is 90-95 percent; conversion of oxygen is complete. The flame reaches an average temperature of 2,700° F. Operating pressure is slightly above atmospheric. Residence time is 0.001-0.01 seconds.

The acetylene is cooled rapidly by a series of sprays located in the lower part of the converter. The cooled gases pass directly to a spray chamber where most of the water is condensed. The gases leave the chamber at 100° F and have the following typical composition (dry basis):

Acetylene	8.5 percent
Hydrogen	57.0 percent
Carbon monoxide	25.3 percent
Carbon dioxide	3.7 percent
Methane	4.0 percent
Higher Acetylenes	0.5 percent
Inerts	1.0 percent
Total	100.0 percent

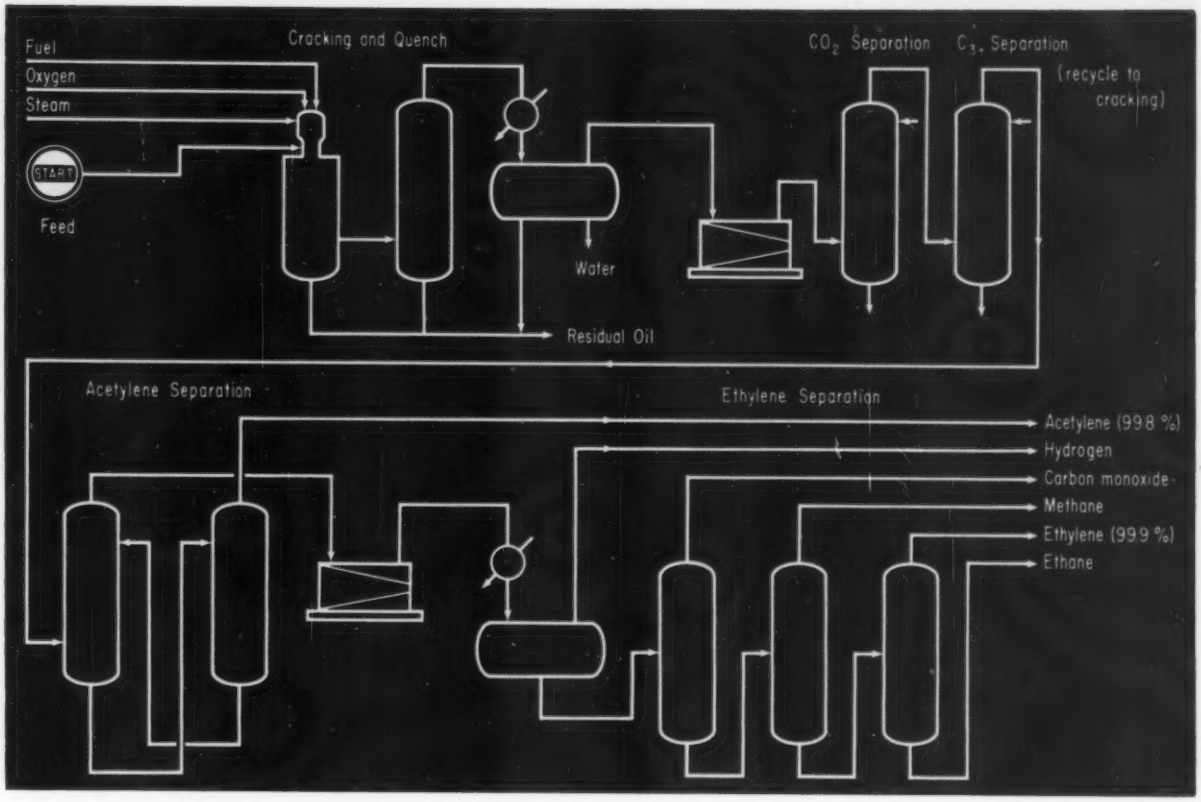
Before the cracked gas can be compressed and separated, residual soot must be removed. The clean cracked gas is then compressed to the head pressure (165 psig) of the concentration system.

The cracked gas passes from the compressor to the main absorber, where acetylene is removed by a selective solvent which shows a high acetylene: carbon dioxide selectivity. Carbon dioxide is removed from the rich solvent by a flashing and stripping operation. Acetylene is stripped from the solvent by conventional flashing and fractionation. Higher acetylenes and water are removed by stripping under reduced pressure. The product acetylene has a purity of 99+ percent with major impurities being methylacetylene, propadiene and carbon dioxide.

Yields: The over-all process yield of acetylene, based on carbon in the natural gas, is 30 percent.

Commercial Installations: This process or a variation is used by Carbide and Carbon Chemicals Company, Texas City, Texas; Monsanto Chemical Company, Texas City, Texas; American Cyanamid Company, Fortier, La.; Rohm and Haas Company, Deer Park, Texas; Monochem, Inc., Geismar, La.

Reference: PETROLEUM REFINER, Dec.'54,p160.



Acetylene and Ethylene—FARBWERKE HOECHST AG

Application: The Hoechst high temperature pyrolysis process for manufacturing acetylene and ethylene from hydrocarbons.

Charge: Feed stocks ranging from methane through middle distillates.

Products: Acetylene of 99.8 percent purity and ethylene of 99.9 percent purity.

Description: Farbwerke Hoechst AG, Frankfurt/Main-Hoechst, Germany, has developed a process which produces a high yield of acetylene and ethylene from hydrocarbon feed stocks. The large amount of high-temperature heat required for the cracking of hydrocarbons into acetylene and ethylene is obtained by combustion of gaseous or liquid fuels with oxygen in a newly developed burner. Combustion with oxygen minimizes the gas volume and permits the use of tail gas as burner fuel. The burner heat release exceeds 10^8 Btu/ft^{3}hr. Its high capacity and all-metal construction minimizes size and weight of the burner. The absence of ceramic parts permits rapid start-up and shut-down. The burner is water cooled and has a very low heat loss.

The feed stock is injected into the hot combustion gas. The mixture enters a reaction zone where the heat necessary to form acetylene and ethylene is transferred by direct contact, with a reaction time of about 0.001 second. An economical and reliable quench method prevents coke formation. The reactor-effluent gas is cooled in steam-generating equipment.

Condensed hydrocarbons are separated and the raw gas is compressed to moderate pressure. Its carbon dioxide and hydrogen sulfide contents are removed by contact with a newly developed absorption agent which is chemically stable, easily regenerated with low-temperature heat, and is noncorrosive. The gas is then cooled and dried, and the C_3 and heavier hydrocarbons are separated. Higher acetylenes, which tend to polymerize, are removed completely and recycled to the reactor.

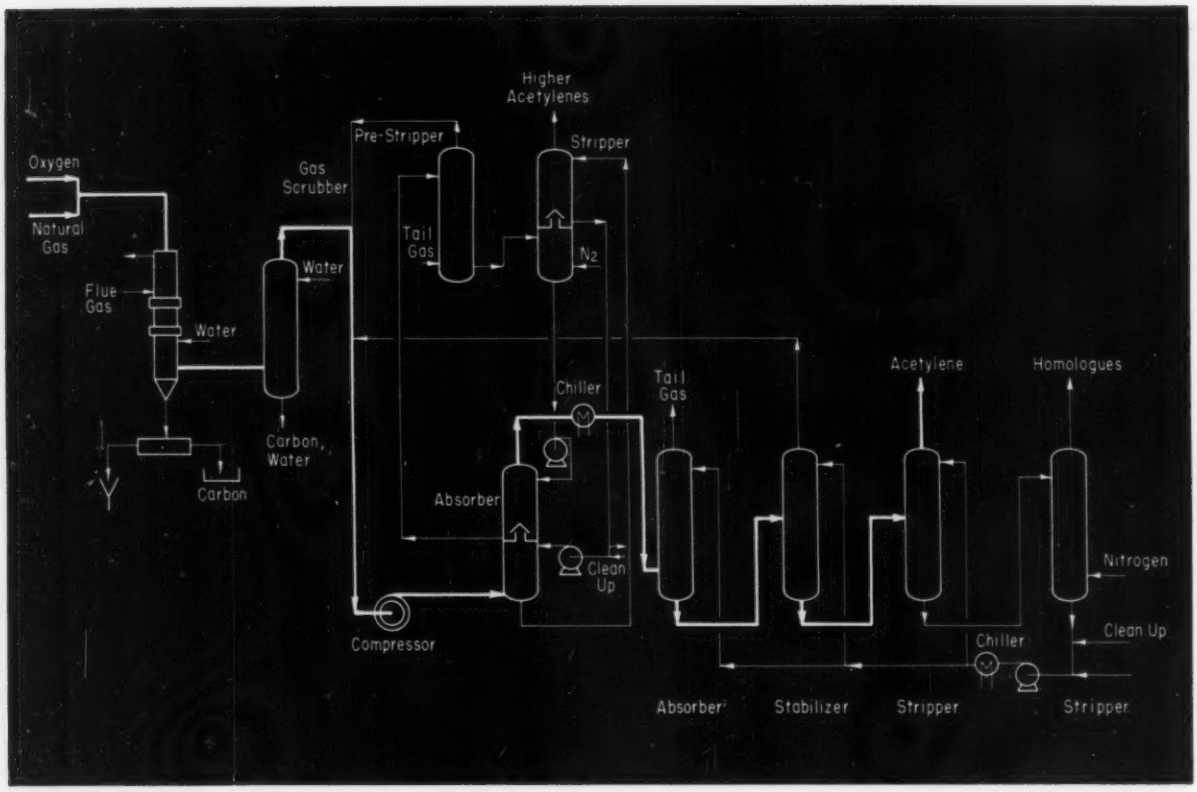
In the next step, a solvent is used to absorb the acetylene, which is recovered as a product of 99.8 percent purity, and higher. A solvent of high selectivity and absorptive power is utilized. This solvent is inexpensive, readily available, and non-corrosive. Regeneration is simple and economical, and solvent losses are low.

High-purity ethylene is separated from the remaining gas by a low-temperature process. The residual gas is rich in hydrogen and may be used as burner fuel. However, if burner fuel is available from other sources, the tail gas may be used for ammonia or methanol synthesis.

Yields: Yields of 50 to 54 wt. percent of acetylene plus ethylene are obtained from light virgin naphtha. A 40 wt. percent yield of acetylene is obtained from methane. These yields are net and after process losses. The ratio of acetylene to ethylene obtained from the burner may be varied from 80:20 to lower than 30:70 by changing operating conditions.

Commercial Installation: A plant designed to produce 100,000,000 lb/yr of acetylene plus ethylene went into operation in 1960 at the Hoechst plant of Farbwerke Hoechst AG in Germany.

References: Further information is available from Hoechst-Uhde Corporation, Empire State Building, Suite 8204, New York 1, N.Y.



Acetylene — HYDROCARBON RESEARCH, INC., DELHI-TAYLOR OIL CORPORATION

Application: A process for the manufacture of acetylene.

Charge: Natural gas.

Products: Acetylene of 99.6 percent purity or higher and synthesis gas byproduct.

Description: The starting point of the process is a newly developed acetylene burner design. Acetylene is generated in a partial combustion reaction, wherein oxygen and natural gas are mixed and preheated in a specially designed preheater to a higher temperature than is used in conventional systems. The preheated mixture is then reacted in a burner of unique design. The oxygen burns part of the feedstock, providing the heat necessary to crack the rest of the feed to acetylene and hydrogen. The reaction is immediately quenched to "fix" acetylene yield and to prevent loss of acetylene by overcracking or polymerization.

The newly developed burner, through the use of higher preheat temperature and efficient burner design, offers the following advantages:

1. Increase in acetylene yield to 9.5 percent acetylene in burner off-gas.
2. Decrease in oxygen and natural gas requirement per ton of acetylene produced.
3. Elimination of carbon deposits on burner walls.
4. Elimination of flashback or pre-ignition.

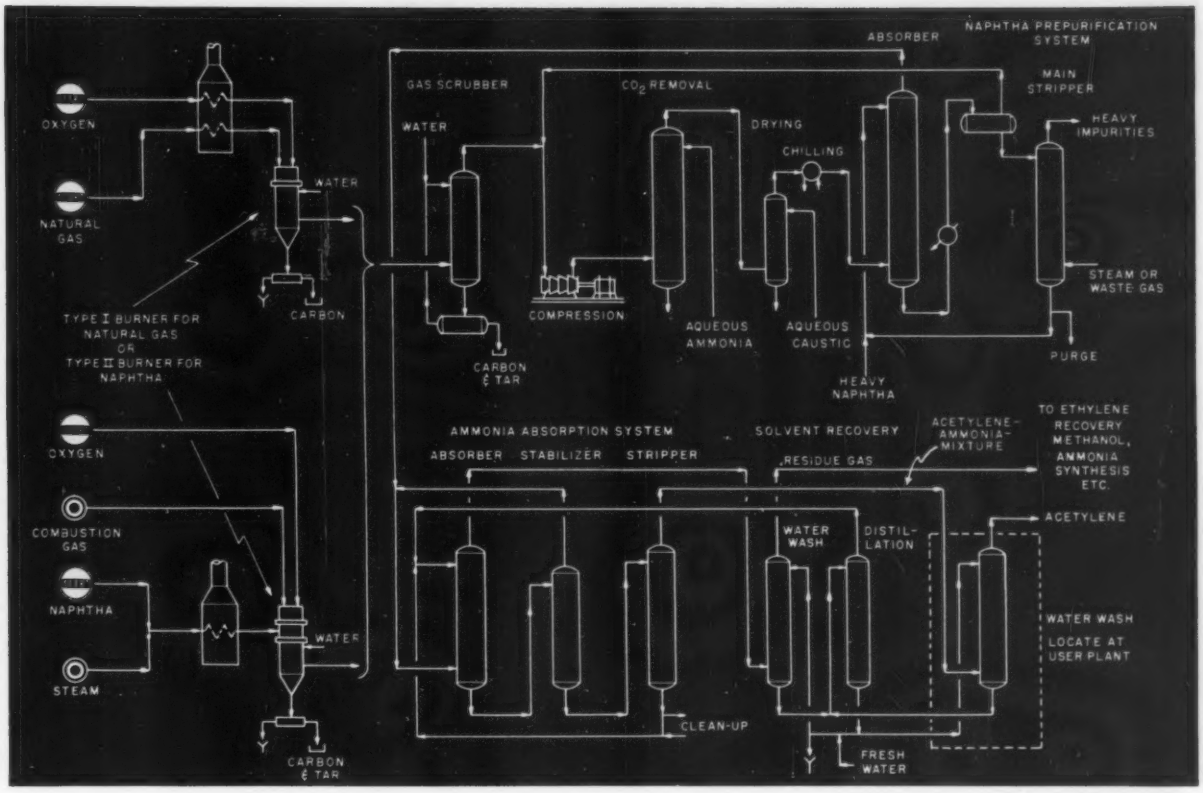
The burner effluent gas passes through a scrubbing system to remove carbon soot and is then compressed before entering the purification system.

The process uses a three solvent system to recover and purify the acetylene. The gas is first scrubbed for tar and aromatics removal. The gas is then scrubbed for the removal of vinyl and di-acetylene. Elimination of these polymerizable materials in these pre-purification steps reduces polymerization to a minimum in the main purification step. Final acetylene purification is achieved with a third solvent absorption system. A solvent of high selectivity and absorptive power is utilized.

The purification system has the advantages of high recovery of acetylene, controlled high product purity, and the availability of the synthesis tail gas at 200 psig. All three solvents are readily available and non-corrosive. Regeneration is simple and economical, and solvent losses are low. All phases of the process have been piloted.

Yields: Acetylene yield from a typical 94 percent methane feed is 27.5 weight percent on feed equivalent to 36 weight percent based on carbon in the feed.

References: Further information is available from Hydrocarbon Research, Inc., 115 Broadway, New York 6, New York.



Acetylene (SBA-Kellogg) — THE M. W. KELLOGG COMPANY

Application: A process for the manufacture of acetylene and ethylene.

Charge: Natural gas, propane, butane, naphtha, or other liquid feedstocks.

Product: High purity acetylene, ethylene.

Description: The Type I Burner is designed for generation of acetylene from natural gas. This is a partial combustion reaction in which oxygen and the feed gas are preheated separately and then mixed and reacted. The oxygen burns part of the feedstock, providing the heat necessary to crack the rest of the feed to acetylene and hydrogen. Small quantities of the higher acetylenes are also formed, and a part of the feed is completely cracked to carbon.

The mixture of pyrolysis and combustion products is then immediately quenched to prevent overcracking and other undesirable side reactions. This quench is an integral part of the burner and also serves to flush out the carbon. The "straight-through" burner design eliminates dead spots where carbon deposits might form. The reaction chamber is water cooled, and the burner design incorporates a movable quench permitting optimum adjustment of the reaction chamber.

Maximum acetylene yields are achieved by using the highest possible preheat temperature, minimizing the amount of combustion required, and increasing the acetylene concentration to the recovery unit by reducing the dilution from combustion products. The burner itself is completely metallic, using no refractories, and requires little maintainance. Burners of over 20 metric tons per day are available.

The Type II Burner is used with liquid feedstocks. This design provides for injection of vaporized feed into an independently formed gas-oxygen flame. Oxygen and fuel gas, mixed with a pre-selected amount of superheated steam, are injected through the head of the combustion chamber. The combustion chamber is formed from a simple, water-cooled refractory ring, the only non-metallic element in the burner. The combustion chamber is also protected by a curtain of steam injected parallel to the walls along the perimeter.

Naphtha, or other liquid feedstock, is mixed with a small quantity of steam, preheated, and injected at high velocity into the burner just below the flame combustion zone. The feedstock cracks primarily to ethylene and acetylene, the ratio of the two being controlled by adjusting the ratio of feed to oxygen and fuel gas. Higher boiling acetylenes and olefins are also formed, and a small amount of feedstock is completely cracked to carbon and tar. As in the case of the Type I Burner, the pyrolysis products are then water quenched after a controlled reaction time.

The burner effluent gas passes through a scrubbing system to remove the carbon and tar which have not been removed by the quench water in the burner.

Following compression, the CO_2 is removed from the gas by scrubbing with an aqueous ammonia-ammonium carbonate solution, followed by a caustic wash. The gas is then dried and cooled.

Precise control of product purity is obtained in the two-solvent recovery system by using heavy naphtha and ammonia for solvents. Purities over 99.5 percent can be readily achieved, and in general any designated impurity can be reduced below the value established by the requirements of the user plant.

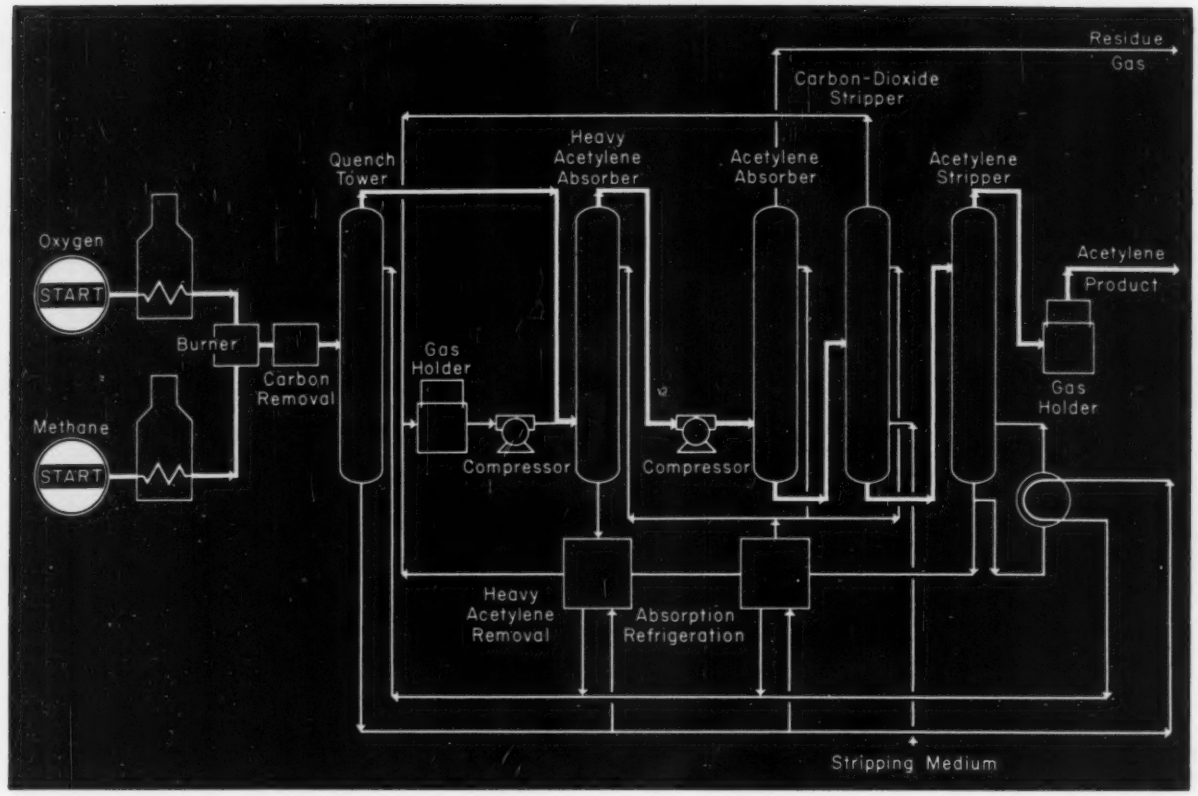
The acetylene-ammonia mixture from the final product stripper is available, under pressure, for safe transport to the acetylene user plant. Final purification to remove the ammonia can be carried out by water wash at the user plant after its pressure is reduced to levels safe for handling concentrated acetylene.

When processing liquid feedstocks, ethylene is a major coproduct recoverable from the residue gas produced in this unit. The ratio of ethylene to acetylene can be controlled over a wide range, varying from less than 0.10 to over 3.0 by weight.

Yields: Acetylene weight percent yield on naphtha varies from 36 to 16 percent over the E/A (wt.) range of 0.1 to 2.0. Acetylene plus Ethylene weight percent yields on naphtha vary from 40 to 50 percent over the same E/A range. Acetylene yield from 95 percent methane feed varies between 24.4 and 25.2 weight percent on feed.

Commercial Installations: Two units are in commercial operation, one in France and a Type II unit in Japan. A 100 MM #/yr. unit in the U.S. using natural gas feed is in the engineering stages.

Reference: PETROLEUM REFINER, Nov. '58, p. 180.



Acetylene — MONTECATINI

Application: A process for making acetylene.

Charge: Natural gas, rich in methane. Oxygen of 95 percent purity, or better. Variations of the process accommodate feedstocks of heavier hydrocarbons, either gaseous or liquid.

Product: Acetylene of 99 plus percent purity.

Description: This description applies only to natural gas. Oxygen and natural gas are preheated in fired heaters. The charge gases are then mixed in a pressure burner, and a partial-combustion reaction takes place. The reaction mixture is quenched with water. The cracked gases contain about eight volume percent acetylene, dry basis.

Temperature for the reaction is about 2,800° F. Pressure is up to six atmospheres absolute. Residence time for the reaction is only a few thousandths of a second.

The soot produced in the Montecatini pressure burner is readily wettable by water. A simple removal system recovers the soot from the main gas stream.

The burner-quenching operation evaporates water in a quantity roughly equivalent to the reaction heat released in the burner. Since the operation takes place under pressure, the quench water can be condensed at temperatures high enough to serve process heating needs. The quench tower recovers enough heat in this manner to satisfy essentially all process requirements.

Heavy acetylenes and aromatic compounds are absorbed in methanol before compression of the cracked gases for acetylene recovery. This step eliminates fouling of the compressor and other equipment by subsequent polymerization of these compounds. The process equipment for the removal of heavy acetylene and aromatics operates at low temperatures to prevent polymerization. Heavy acetylenes and aromatics are ultimately burned on plot at a fuel credit to the process.

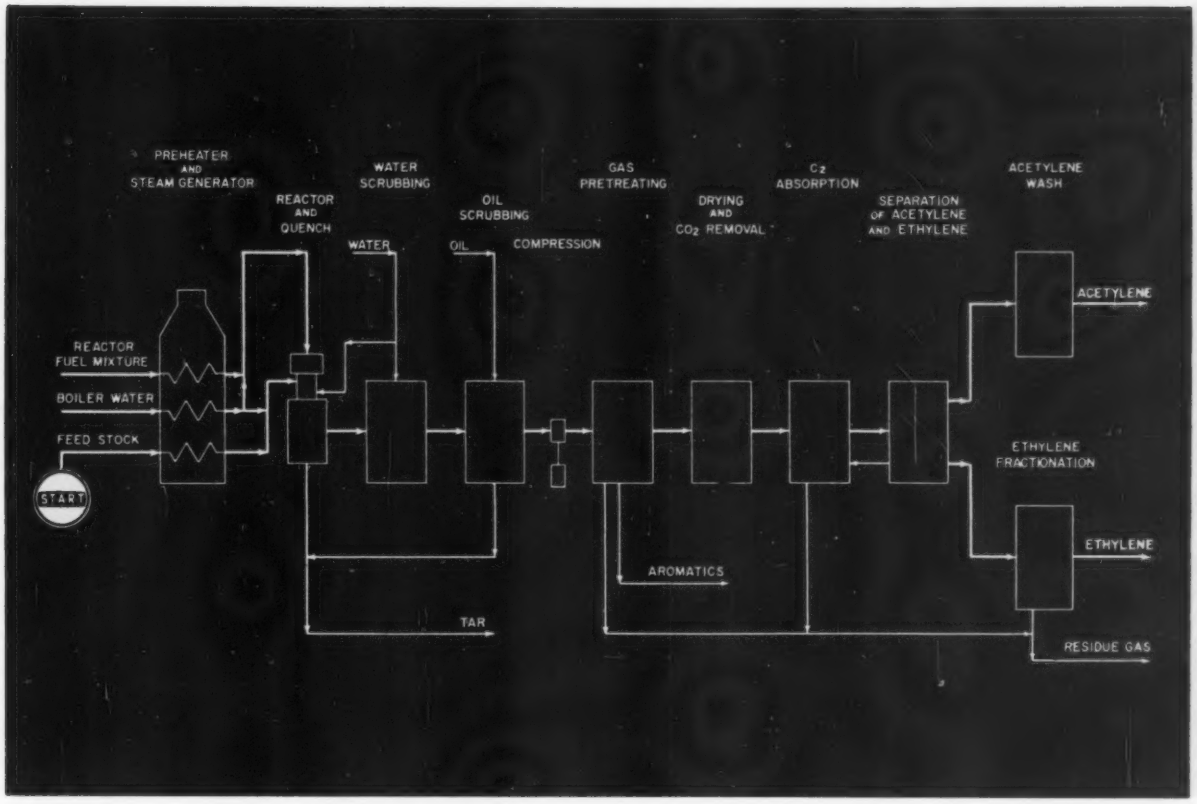
After compression of the cracked gases, the acetylene and some carbon dioxide are absorbed in chilled methanol. Conventional absorption and stripping techniques separate carbon dioxide and recover acetylene from the solvent.

Product acetylene purity is greater than 99 percent. The impurities are carbon dioxide and trace quantities of propadiene and methyl acetylene.

Yields: The over-all process yield of acetylene is 23 percent, based on the weight of the natural gas. The residue gas contains hydrogen and carbon monoxide in the ratio of about two to one. It can be either burned as fuel or used as synthesis gas for the production of ammonia or methanol.

Commercial Installations: The first pressure burner was commercially demonstrated in early 1959, in Montecatini's 15 million pounds-per-year acetylene plant at Novara, Italy. Since then seven companies throughout the world have licensed the process. Plants are under construction in Czechoslovakia, Italy, Japan, Poland, Russia—and in USA at Deer Park, Texas, for Diamond Alkali Company.

Reference: Montecatini Pressure Acetylene Process, April 1961, published by C F Braun & Co, Alhambra, Calif.



Acetylene and Ethylene (EASTMAN PROCESS)—STONE & WEBSTER ENGINEERING CORP.

Application: A process for the simultaneous production of acetylene and ethylene.

Charge: Ethane, propane, butane, light naphtha.

Products: Acetylene, ethylene, synthesis gas.

Description: The hydrocarbon feed is converted into acetylene, ethylene and byproduct gas by short time pyrolysis in a stream of hot combustion products in a reactor of special design. The reactor consists of five elements in series: a fuel burner, a combustion chamber, a feed injection zone, a reaction zone and a quenching section.

Fuel gas and air, or oxygen, are burned in the combustion chamber, and the hot gases enter the mixing duct at high velocity. The hydrocarbon to be pyrolyzed is injected into the turbulent combustion gas stream where rapid and uniform mixing is attained. The reaction section provides the additional small residence time required for completing the pyrolysis to maximum yields of acetylene and ethylene, after which the gas mixture is rapidly quenched by water sprays to relatively low temperatures.

Steam is introduced with the fuel and oxygen, to temper the combustion temperature and to serve as a heat carrier. Steam is also admitted with the feed stock as a diluent, producing a partial pressure favorable to the desired pyrolysis reaction. The proportion of acetylene to ethylene is governed principally by the reaction temperature level, which may be varied easily by changing the quantity of combustion gas used, or the quantity of feed injected. Acetylene to ethylene ratios of 0.3/1 up to 4/1 have been demonstrated.

A water quench spray is located at the outlet of the reaction zone, and the effluent passes into a tar knockout drum where most of the small amount of tar made settles out and is drawn off. The gases then pass into a water scrubbing tower where they are cooled to about 100° F, and the steam in the gases is condensed. In the oil scrubber which follows, a circulated stream of oil removes fine particles of tar and heavy oils from the gas. Cleanup of the circulating oil is effected by steam in a stripping column. The residue tarry oil from this stripper is mixed with the tar from the quench drum, so that a freely flowing material results.

The scrubbed gas is compressed and sent to a pretreating section, where oil absorption removes material heavier than acetylene and ethylene.

Conventional carbon dioxide removal and dehydration treatment are the final steps in preparing the gas for entry into the recovery system.

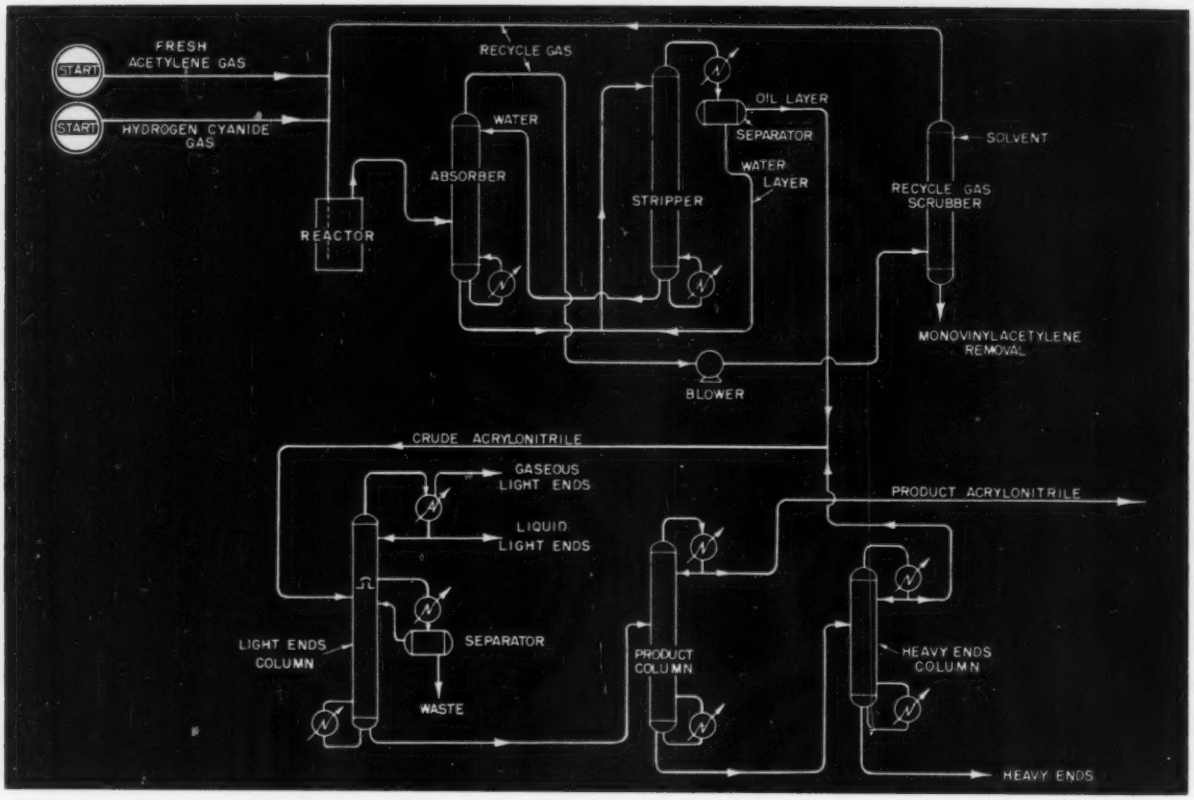
The recovery system employs a combination of absorption and extraction steps with hydrocarbon and organic solvents to recover acetylene and ethylene from the gas. Suitable purification steps are included to produce acetylene and ethylene at high purities.

Operating Conditions: The reactor operates substantially at atmospheric pressure and at a flame temperature of about 2,000° C.

Yields: A combined yield of acetylene and ethylene of over 50 weight percent on the charge is obtained.

Commercial Installations: Reactor in commercial operation at Chemische Werke Hüls, Germany, demonstrated a combustion chamber refractory life of more than two years.

Reference: *Chem. Engr. Progress,* Vol.54,No.1,'58,p41-48.



Acrylonitrile—AMERICAN CYANAMID COMPANY

Application: A process for manufacturing acrylonitrile from acetylene and hydrogen cyanide.

Charge: Acetylene gas (99 percent purity); hydrogen cyanide gas (99+ percent purity).

Product: Acrylonitrile liquid of 99.5 percent purity.

Description: Acrylonitrile may be produced either by the dehydration of ethylene cyanohydrin or by the direct combination of acetylene and hydrogen cyanide. The latter method is known as the "natural gas process." It is the more important method today, commercially, and accordingly will be described here.

Acetylene and hydrogen cyanide in a ratio of 6:1 form the reactor charge. The reactor is a rubber-lined cylindrical vessel containing liquid catalyst to a depth of several feet. The reactants are injected separately under the liquid surface. About 15 percent of the acetylene is converted, and this consumes practically all of the hydrogen cyanide.

The aqueous catalyst consists of cuprous chloride, hydrogen chloride, and alkali chlorides in 36 weight percent water. All salts are in solution at 175° F which is also the reaction temperature. Yields of 1.5 pounds of acrylonitrile per hour-foot^3 of solution are obtained. The catalyst must be regenerated to prevent deactivation.

The reaction pressure is 2-5 pounds above atmospheric.

The reaction products pass to an absorber, the lean gas from which contains acetylene and divinylacetylene. The latter constituent is removed in a separate scrubbing operation. The residual acetylene is recycled through a blower to the reactor charge.

The absorber is operated at a water rate such that a three percent acrylonitrile solution is withdrawn as bottoms. This stream is sent to the stripper, from which a crude acrylonitrile-water azeotrope is recycled to the stripper feed. The oil layer, or "crude acrylonitrile," is sent to a distillation train for separation and purification.

The concentration of acrylonitrile in the crude solution is about 75 weight percent; that of the materials other than water is about 15 weight percent.

The first tower in the distillation train (light ends column) enables the overhead removal of materials boiling below acrylonitrile. Acetylene and monovinylacetylene pass off as gases.

Product acrylonitrile, having a purity of about 99.5 percent on a dry basis, is removed as overhead from the second column. The operating head pressure is about 140 mm Hg abs. The bottoms stream contains heavy ends plus a significant amount of acrylonitrile.

The third tower in the train, the heavy ends column, serves to recover acrylonitrile from the product column bottoms. The heavy ends column operates at a head pressure of 120-150 mm Hg abs. The recovered acrylonitrile is not specification-grade and must be recycled to the light ends column.

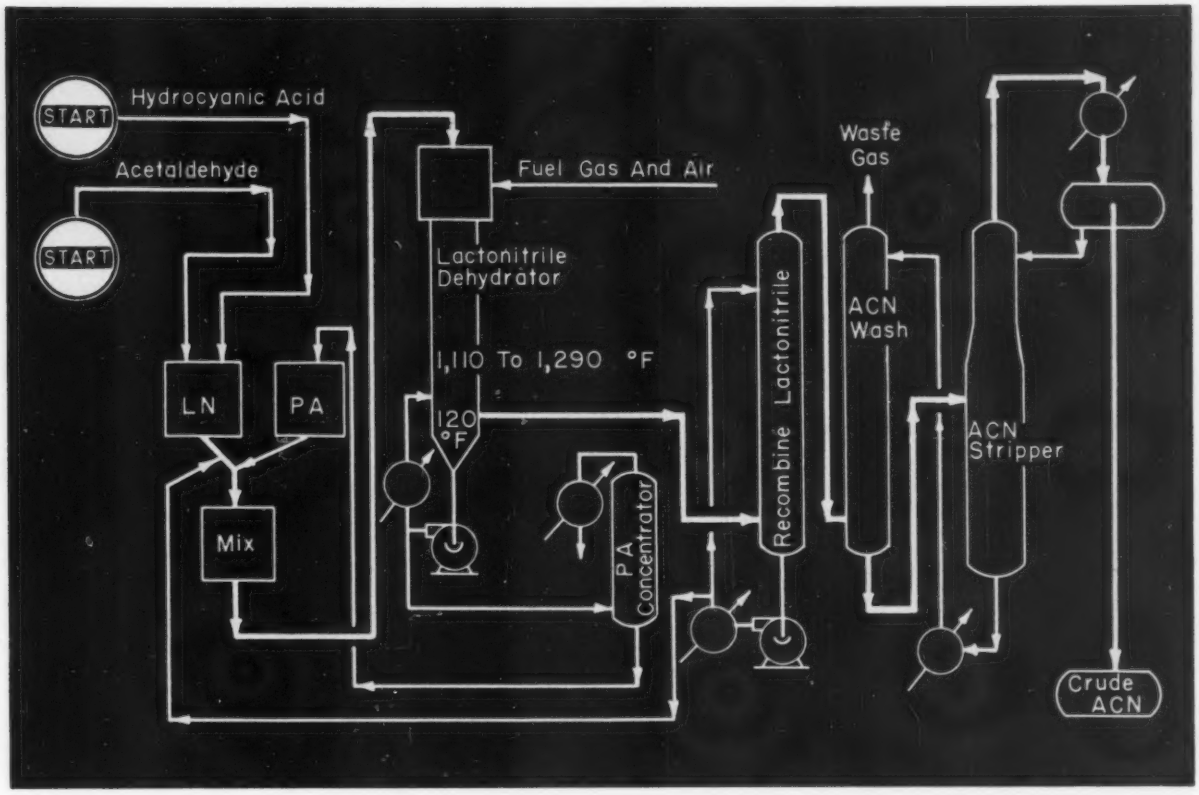
The product acrylonitrile has a boiling range of 169°-173° F.

Operating Conditions: The important operating conditions are those in the reactor. They are defined in the above text.

Yields: Typical over-all process yields are:
Acrylonitrile from HCN, 85 percent.
Acrylonitrile from C_2H_2, 75 percent.

Commercial Installations: Plants utilizing the methane process are: Monsanto Chemical Company, Texas City, Texas; American Cyanamid Company, Fortier, La.: The B. F. Goodrich Company, Calvert City, Ky.

References: "The Manufacture of Acrylonitrile From Natural Gas," J. T. Thurston, E. L. Carpenter, and F. Derbenwick of American Cyanamid Co., Fourth World Petroleum Congress, Rome, Italy.



Acrylonitrile (Knapsack) — HOECHST-UHDE CORPORATION

Application: A process for the manufacture of acrylonitrile from acetaldehyde and hydrocyanic acid.

Description: Lactonitrile of 97-98 percent purity is produced from acetaldehyde and hydrocyanic acid at a pH of 7.0-7.5 and a temperature of 50°-65° F, according to the following reaction:

$$CH_3CHO + HCN \rightarrow CH_3CH(OH)CN + 30.4\ BTU$$

Lactonitrile is mixed with 80-85 percent aqueous phosphoric acid in a molecular ratio of 3:1 and is sprayed into a reaction furnace where the mixture is heated within a fraction of a second to 1110°-1290° F by contact with high-temperature combustion gas. The hot gas, at 1800°-2700° F, is obtained by combustion of fuel gas with 90 percent of the theoretical air requirement. The reaction gases are quenched at the furnace outlet by a recirculating stream of 30 percent aqueous phosphoric acid. Approximately 75 percent of the lactonitrile is thus converted to acrylonitrile and water. Most of the remainder splits to form acetaldehyde and hydrocyanic acid, and about 2-3 percent saponifies to ammonium phosphate and lactic acid.

The 30 percent aqueous phosphoric acid from the quenching operation is reconcentrated to 80-85 percent and is recycled to the reaction furnace. The reaction gases are directed to a venturi scrubber where the remaining phosphoric acid mist is removed.

The hydrocyanic acid and acetaldehyde contained in the reaction gases are converted to lactonitrile in a recombining tower and the lactonitrile is pumped to the reaction furnace. The acrylonitrile content of the reaction gases is removed by absorption in water at 68° F. Recovery of crude acrylonitrile from the 2-3 percent aqueous solution is accomplished in a stripper by direct heating with steam.

The crude acrylonitrile is finally directed to a distillation section comprising two columns in a series. The water content is removed in the first column, as well as small quantities of lactonitrile, acetaldehyde, and hydrocyanic acid. Pure acrylonitrile is the overhead product from the second column. A residue of high-boiling nitriles, equivalent to 2.5-3 percent of the acrylonitrile production, is obtained from the bottom of the second column.

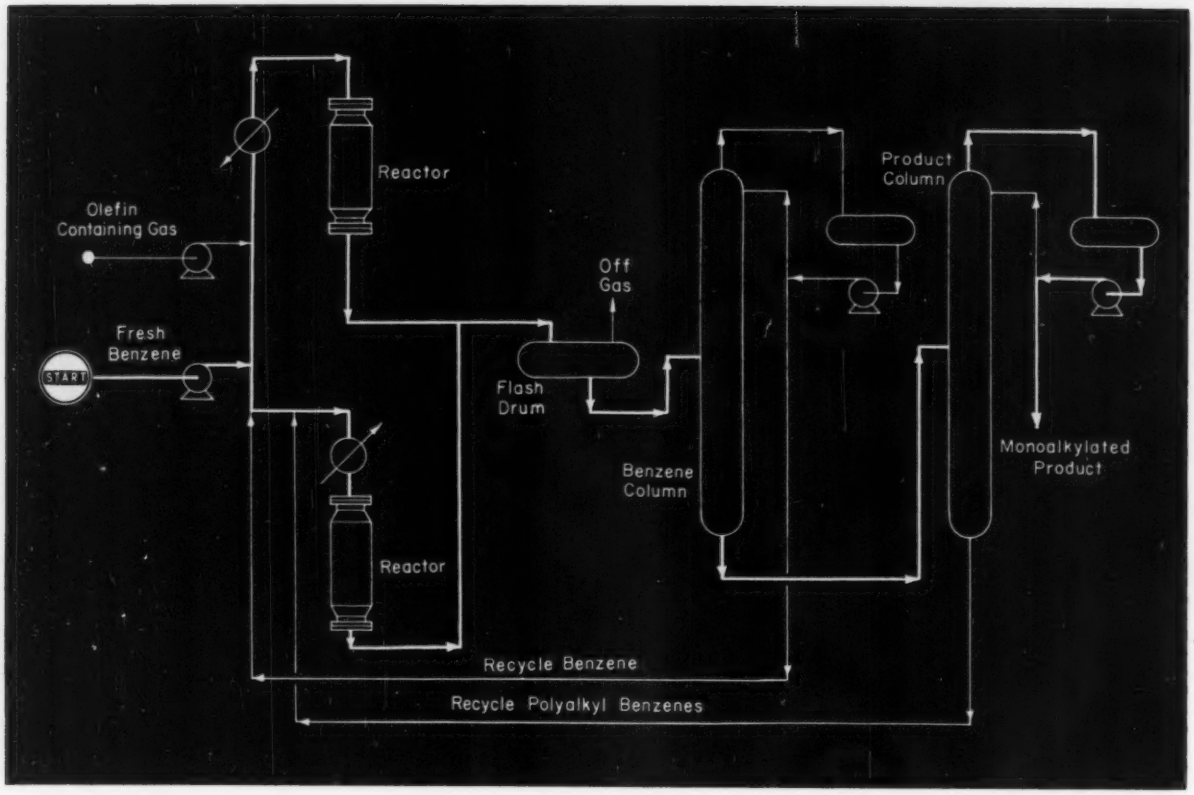
The problem of phosphoric acid corrosion at the high temperatures involved has been met through use of suitable materials. The ammonium phosphate produced by the 2-3 percent saponification of lactonitrile is concentrated in the recycle acid and crystallizes at a concentration of 15-20 percent in the lactonitrile mixture. It is removed by filtration. The ammonium phosphate production is approximately 7-8 pounds per 100 pounds of acrylonitrile produced. This material is at least as valuable as the equivalent phosphoric acid.

The acrylonitrile produced by the Knapsack Process is particularly suitable for the manufacture of high-quality polymers.

A pilot plant of 30 tons/month acrylonitrile capacity has been operated in the plant of Knapsack-Griesheim AG, near Cologne, Germany.

Yields: The yields of acrylonitrile based on the quantities of acetaldehyde and hydrocyanic acid reacted are 90 and 92 percent respectively, and may be improved as the development of the process is advanced.

References: Sennewald, K., Steil, K. H., *Chemie-Ingenieur Technik* No. 7, 440-446 (1958); Sennewald, K., "Acetaldehyde as Raw Material for Acrylonitrile." Paper presented at Fifth World Petroleum Congress, New York, 1959.



Alkar—UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for alkylating aromatics with olefins to obtain a 100 percent yield of the monoalkylaromatics. The process may also be used to obtain substantially quantitative yields of dialykyl- and polyalkylaromatics. A particularly important feature of this process is its ability to utilize low concentrations of olefins in the feed gas such as in the off-gas from catalytic cracking. The principal application of the process currently is in the manufacture of high-purity ethylbenzene for styrene production. It may also be used, however, to produce diethylbenzene or a combination of mono- or polyalkylbenzenes. Acetylene, if present in the feed gas, is selectively converted to 1,1-diphenylethane. Toluene, xylenes, and other aromatics also may be alkylated. It is possible to alkylate aromatics in a mixture with paraffins and naphthenes.

Charge: Benzene, or other aromatics, and an olefin-containing gas. This gas may be off-gas from catalytic cracking operations, off-gas from a demethanizer in an ethylene purification unit, or gases from the pyrolysis of hydrocarbons.

Products: Alkylaromatics of high purity and exceptionally low olefin content. The low olefin content is achieved because the unique catalyst is selectively active for alkylation reactions, polymerization of the olefin being virtually absent.

Process Description: The purified olefin-containing gas and feed benzene are combined with recycle benzene and similarly, recycle polyaromatics are combined with recycle benzene. The combined feeds are raised to reaction temperature and enter the respective reactors. Conversion of the olefins in the feed gas to alkylbenzenes is virtually complete. Polyalkylbenzenes and benzene are transalkylated to yield monoalkylated products.

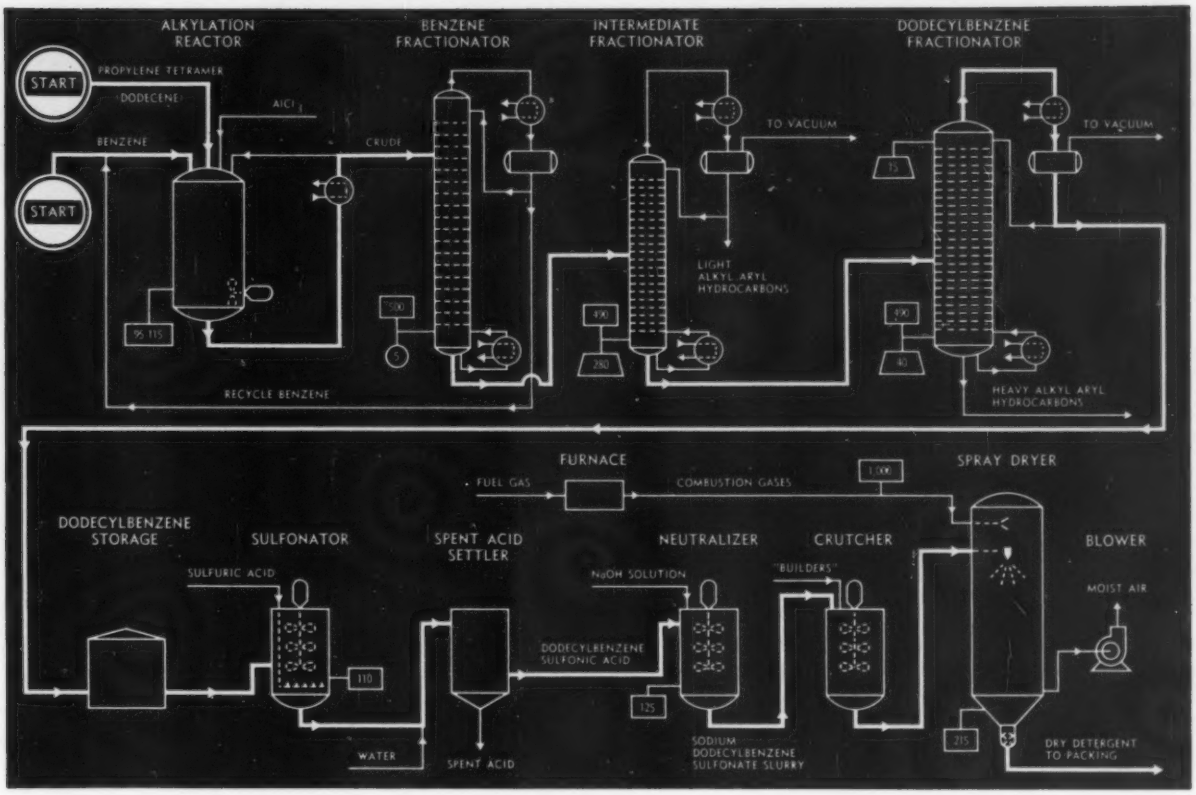
The reactor effluent is flashed to remove inert gases. The liquid from the flash drum is charged to the benzene column; recycle benzene is taken overhead and returned to the reactor. Alkylbenzenes are distilled to yield the monoalkylated product and the polyalkylbenzenes normally are recycled for transalkylation.

Operating Conditions: Operating conditions are moderate and no corrosion problems are encountered. Carbon steel may be used throughout the plant.

Yields: Olefins in the feed gas in concentrations as low as a few percent are converted almost completely on a one-pass basis. Yields of virtually 100 percent monalkylated products are obtained.

Commercial Operations: Two units are in operation and several others are in design or construction stages.

References: *Oil & Gas J.*, Vol.56,No.13(Mar.31,'58); *Petroleum Week*, Mar.28,'58,p38.



Alkyl Aryl Sulfonates— CONTINENTAL OIL COMPANY

Application: A process for the manufacture of dodecylbenzene sulfonate synthetic detergents.

Charge: Benzene, dodecene (propylene tetramer), sulfuric acid, caustic soda, and "builders."

Product: Finished detergent containing 15 to 40 percent sodium dodecylbenzene sulfonate.

Description: This process involves reaction of dodecene with benzene in the presence of aluminum chloride catalyst; fractionation of the resulting crude mixture to recover the desired boiling range dodecylbenzene; sulfonation of the dodecylbenzene and subsequent neutralization of the sulfonic acid with caustic soda; blending the resulting slurry with chemical "builders"; and drying.

Dodecene (350°-420° F boiling range) is charged into a reaction vessel containing benzene and aluminum chloride. The reaction mixture is agitated and circulated through an external cooler to maintain the reaction temperature at about 115° F. maximum. An excess of benzene is used to suppress the formation of by-products. Aluminum chloride requirement is 5-10 weight percent of dodecene. The reaction may be carried out using hydrofluoric acid or sulfuric acid in place of aluminum chloride.

After removal of aluminum chloride sludge, the reaction mixture is fractionated to recover excess benzene which is recycled to the reaction, a light alkyl-aryl hydrocarbon, dodecylbenzene, and a heavy alkyl-aryl hydrocarbon. The dodecylbenzene is a water-white liquid having a boiling range of 530°-600° F.

Sulfonation of the dodecylbenzene may be carried out continuously or batch-wise under a variety of operating conditions using sulfuric acid (100 percent), oleum (usually 20 percent SO_3) or anhydrous sulfur trioxide. The optimum sulfonation temperature is usually in the range of 100°-400° F depending on the strength of acid employed, mechanical design of the equipment, etc. Removal of spent sulfuric acid from the sulfonic acid is facilitated by adding water to reduce the sulfuric acid strength to about 78 percent. When anhydrous sulfur trioxide is the sulfonating agent, there is no spent acid removal problem and the sulfonic acid is ready for further processing immediately after sulfonation.

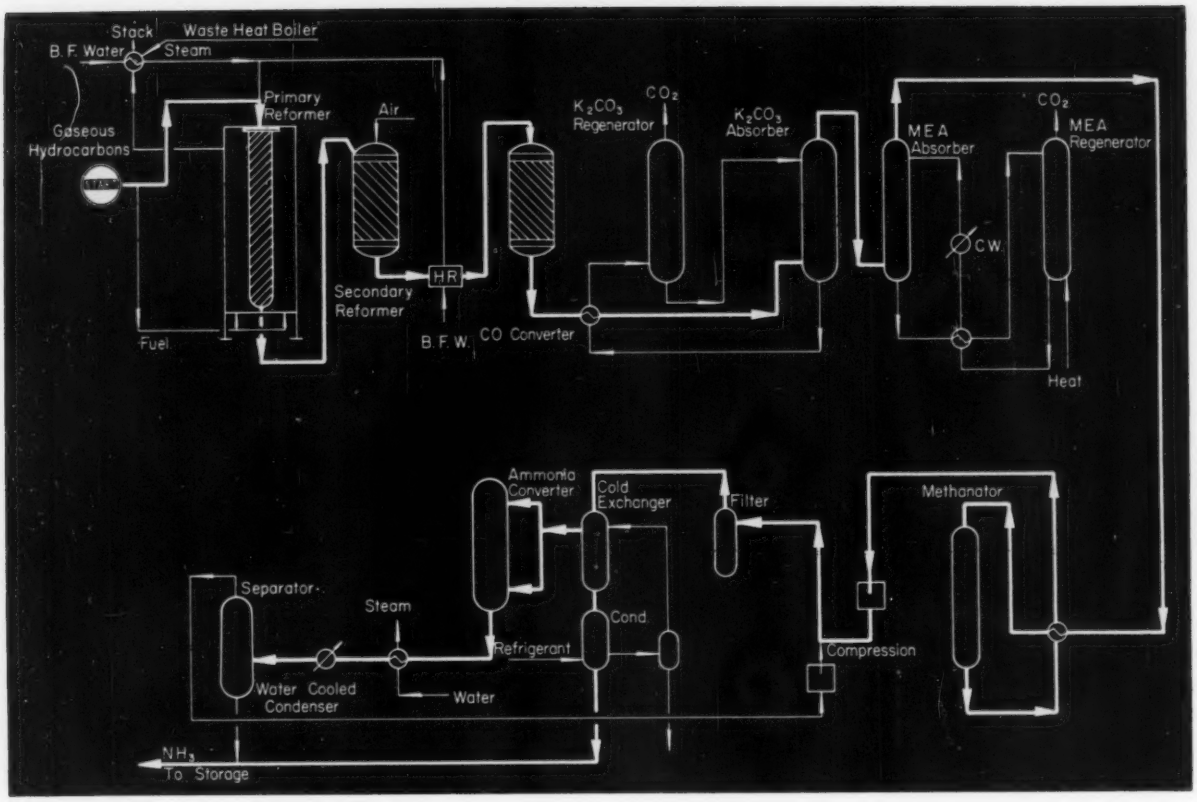
The sulfonic acid is neutralized with 20-50 percent caustic soda solution to a pH of 8 at a temperature of about 125° F. Chemical "builders" such as trisodium phosphate, tetrasodium pyrophosphate, sodium silicate, sodium chloride, sodium sulfate, carboxymethyl cellulose, etc., are added to enhance the detersive, wetting or other properties desired in the finished product. A flaked dried product is obtained by drum drying, or a bead product is obtained by spray drying.

Operating Conditions: Refer to the above text and flow diagram.

Yields: Alkylation, 75 percent; sulfonation, substantially 100 percent; drying, 95 percent or greater.

Commercial Installations: Continental Oil Company, Baltimore, Md., and Chicago; Atlantic Refining Company, Philadelphia, Pa.; Oronite Chemical Company, Richmond, Calif., and Monsanto Chemical Company, St. Louis, Mo., use processes similar to this.

References: PETROLEUM REFINER, July,'54,p157; *Ind. Eng. Chem.*, **46**, 1925 (1954); *Ind. Eng. Chem.*, **46**, 248 (1954); *J. Am. Oil Chemists' Soc.*, 31, 200 (1954).



Ammonia — CHEMICAL CONSTRUCTION CORPORATION

Application: This is a process for the production of ammonia.

Charge: The feed to the process may be any mixture of lower molecular weight gaseous hydrocarbons consisting primarily of saturates, acetylene off-gas, or a mixture of hydrocarbons and off-gas.

Description: The feed gases are reformed by reaction with steam at any pressure up to 300 psig. Optimum pressure is selected for the particular gas to be processed. Process steam requirements are generated in waste heat boilers.

Most of the hydrocarbons are reformed to hydrogen, carbon monoxide and carbon dioxide in the primary reformer. Heat for the reaction is supplied by liquid or gaseous fuels.

The reactions are completed in the secondary reformer where the correct amount of nitrogen to form a 3:1 hydrogen-nitrogen ratio enters with the air. Necessary heat is supplied by reaction of combustible products with oxygen in air.

Heat in gases exit the secondary reformer and is recovered as steam for use in the process. Most of the carbon monoxide formed by reforming is converted to carbon dioxide in the CO converter by reaction with steam to form hydrogen and carbon dioxide.

The gas stream is cooled in a reboiler, supplying heat for CO_2 removal solution regeneration.

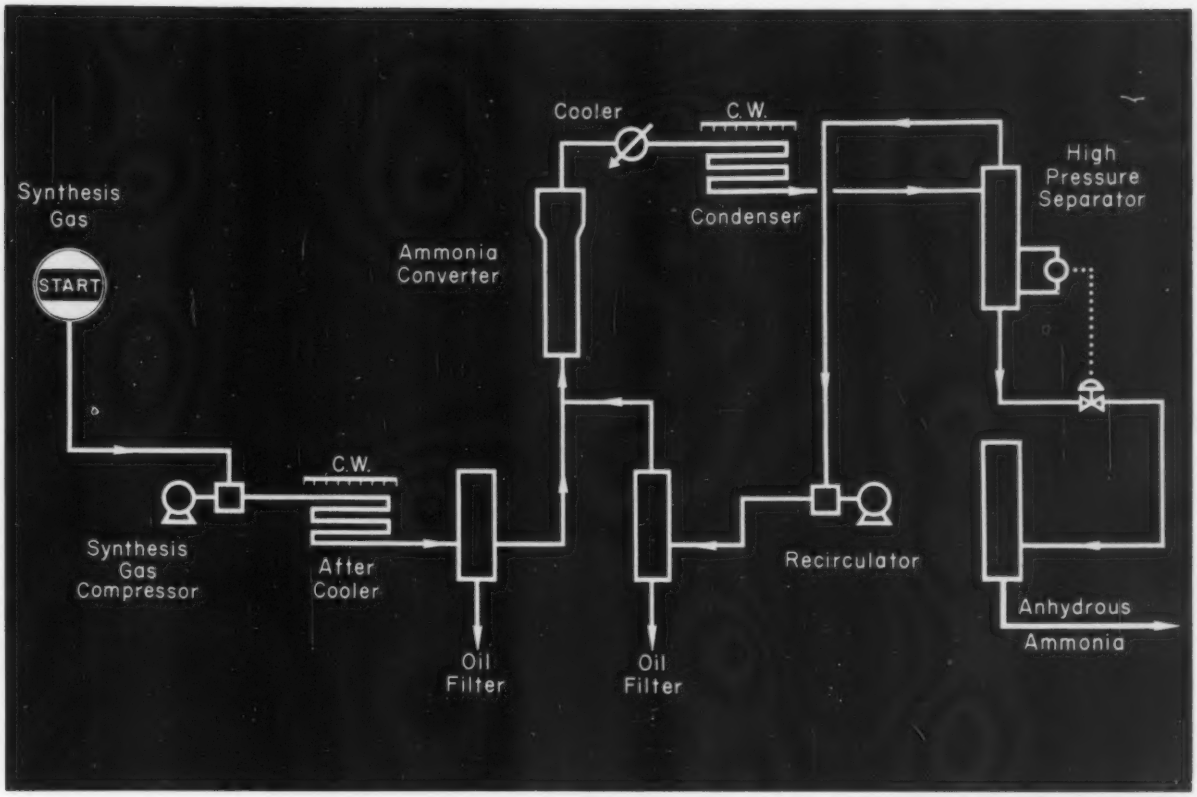
The bulk of CO_2 is removed from the synthesis gas stream by regenerative liquid absorption, using either a combination of hot potassium carbonate and monoethanolamine (MEA) in successive stages or two stages of MEA. Final cleanup is accomplished by methanation, reducing oxides to 10 ppm. or less.

After purification the gas is compressed to 5,200 psig and synthesized to ammonia as illustrated in the flow diagram. Production of steam in the synthesis loop is optional depending on economic considerations for a particular plant.

Products: Anhydrous liquid ammonia with a minimum purity of 99.9 percent.

The carbon dioxide produced is of sufficient purity to be reused for the production of dry ice or urea especially where K_2CO_3 scrubbing is used.

Commercial Installations: There are seventy-six Chemico designed ammonia synthesis plants ranging in size up to 450 T/D in operation all over the world.



Ammonia (Claude Process)—THE FLUOR CORPORATION, LIMITED

Application: A process for the manufacture of anhydrous ammonia.

Charge: Feed to the ammonia synthesis unit is gas containing 75 percent hydrogen and 25 percent nitrogen. Such synthesis gas may be produced from catalytic reformer off-gas, butadiene off-gas, coke oven gas, electrolytic cell hydrogen, or other sources by nitrogen scrubbing. It may also be produced by steam methane reforming or partial oxidation of natural gas or other hydrocarbons.

Product: Liquid anhydrous ammonia of 99.9 percent purity.

Description: Synthesis gas containing 75 percent hydrogen and 25 percent nitrogen flows to the synthesis gas compressors for compression to about 400-600 atmospheres, cooled, passed through a lube oil removal unit, blended with recycle gas, and fed into the Claude Converter. The gases enter the Claude Converter at about 100° F and internal heat exchange increases this temperature to a suitable level for rapid conversion to ammonia. The exothermic reaction raises the temperature level within the converter to about 1100° F, but this heat is transferred to the incoming feed gas so that the gases leave the converter at about 480°-510° F. The effluent gases pass through the tubes of a water-cooled condenser which condenses most of the ammonia produced, allowing a very small fraction to recycle with the unconverted gases. The anhydrous ammonia produced is passed to storage through an automatic let-down valve. Unconverted gases are recompressed and passed through a filter for lube oil removal before passing back to the converter inlet.

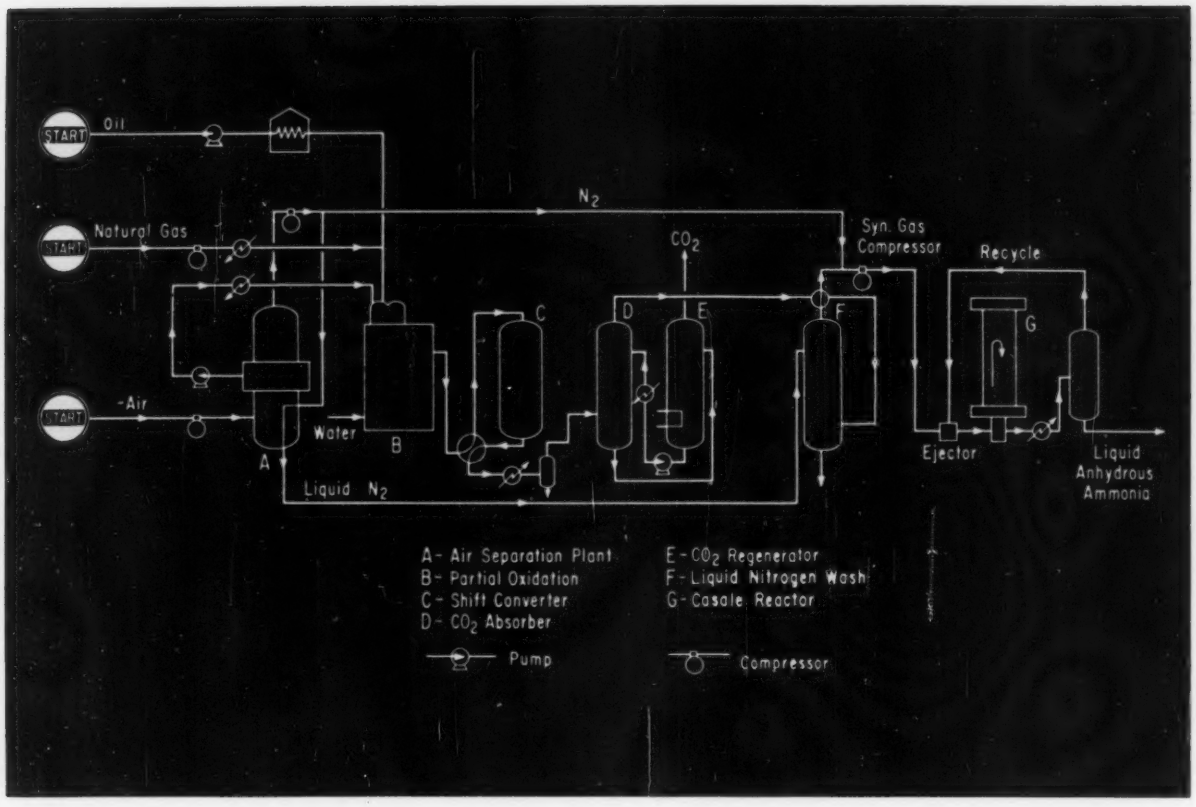
Synthesis gases purified in a liquid nitrogen scrubbing unit are so pure that no vapor purge from the loop is necessary. An equilibrium is established wherein the small quantity of inerts introduced with the syn gas passes from the high pressure separator dissolved in the liquid ammonia as long as inerts in fresh synthesis gas are less than 250 ppm.

Operating Conditions: The synthesis converter starts producing at about 400 atmospheres, and most of the ammonia production is made near that level. The converter is designed to permit operation as high as 600 atmospheres, which will occur after the catalyst has aged.

Yield: About 97 percent based on nitrogen and hydrogen.

Commercial Installations: The Claude converter is in use at Mississippi River Chemical Company, Selma, Missouri; Hercules Powder Company, Pinole, California; Mississippi Chemical Corporation, Yazoo City, Mississippi; San Jacinto Chemical Company, Houston, Texas; Ketona Chemical Company, Ketona, Alabama; and Calumet Nitrogen Products Company at Whiting, Indiana. A plant incorporating the Claude Converter is under construction for Petroleos Mexicanos at Minatitlán, Mexico.

Reference: *Chem. Eng. Progress,* 48, 468 (1952).



Ammonia— FOSTER WHEELER CORPORATION

Application: A process for manufacturing ammonia.

Charge: Hydrocarbon oil and/or gas, water and air.

Product: Liquid Anhydrous Ammonia.

Description: The processing sequence for the synthesis of ammonia comprises six steps: air fractionation, partial oxidation, shift conversion, carbon dioxide removal, liquid nitrogen wash and ammonia synthesis.

An alternate processing sequence would involve catalytic reaction of steam with hydrocarbon gases (the steam-methane reaction) in place of partial oxidation.

Air, filtered and caustic scrubbed, is compressed to approximately 600 psig, liquefied and separated into nitrogen and oxygen in the air separation plant. The nitrogen is compressed and the bulk of it is used for blending into the purified synthesis gas. A slip stream of this nitrogen re-enters the air plant and is liquefied for use in the liquid nitrogen wash tower. Liquid oxygen is pumped thru a preheater to the Texaco generator.

Preheated hydrocarbon oil/water mixture (or hydrocarbon gas) also enters the generator, mixes with the oxygen and the highly exothermic reaction takes place. The products, mainly carbon monoxide and hydrogen, are quenched with water and enter the shift converter where in the presence of a catalyst, carbon monoxide reacts with steam to form additional hydrogen and carbon dioxide. The effluent from the shift converter passes through a heat exchanger for recovery of process heat, is cooled, flows through a liquid knockout drum and then to the carbon dioxide removal system.

Carbon dioxide is removed by absorption in a suitable medium such as monoethanolamine which is then reactivated by heat, releasing the carbon dioxide to battery limits.

The hydrogen stream then enters the liquid nitrogen wash tower where residual carbon monoxide, methane and argon are removed. The purified hydrogen is blended in specified proportions with nitrogen, produced at the air separation plant, and enters the Casale synthesis system.

The gaseous mixture of hydrogen and nitrogen is compressed to approximately 9,000 psig and enters the reactor, via the jet ejector system which serves to return the uncoverted recycle gases to the reactor. The ammonia synthesis is completed in the presence of a special catalyst.

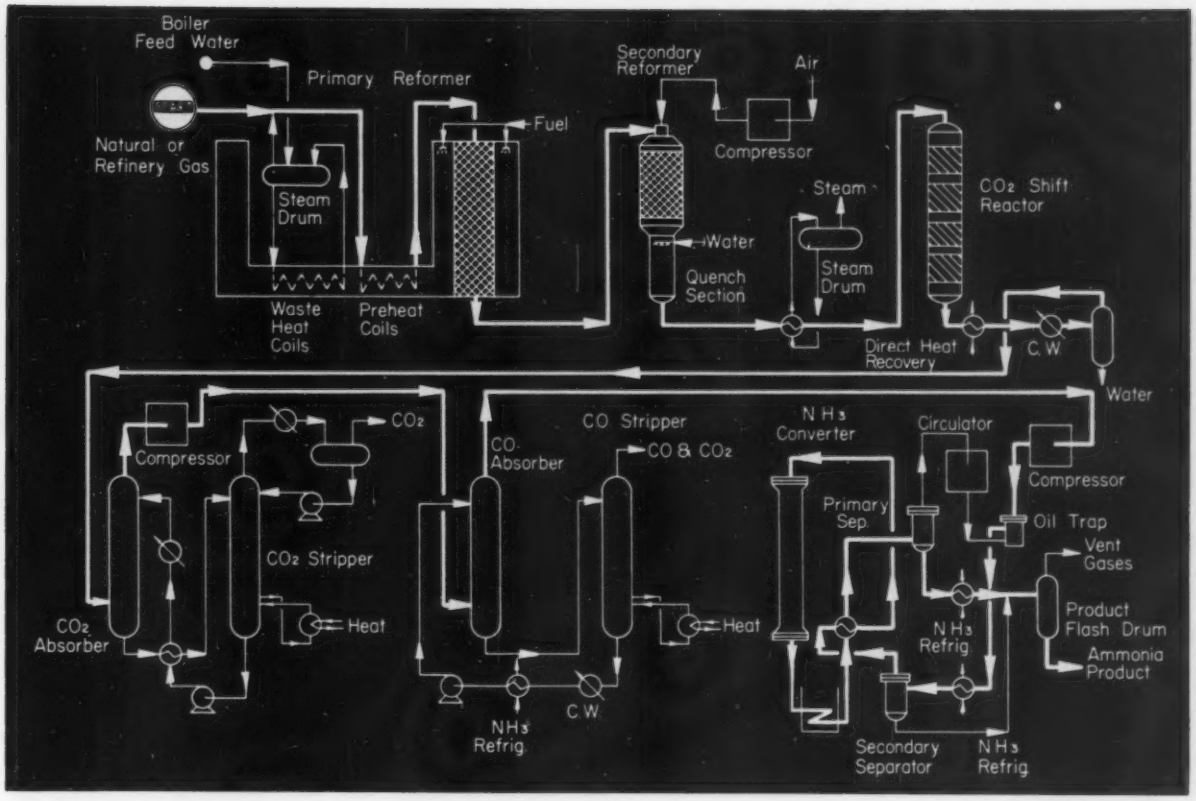
The effluent gases are cooled, the anhydrous ammonia is condensed and separated from the unconverted gases which are returned to the reactor via the ejector system. The liquid anhydrous ammonia flows to storage.

The ejector system eliminates the necessity for a recirculating compressor for the unconverted gases.

Operating Conditions: Important operating conditions are mentioned in the above description.

Commercial Installations: Over 2000 tons per day of installed capacity.

References: PETROLEUM REFINER, Sept.'53,p178; CHEMICAL ENGINEERING, May'54,p332.



Ammonia — THE M. W. KELLOGG COMPANY

Application: A high pressure steam methane reforming process for ammonia production.

Charge: Natural gas, refinery gas, coke oven gas or light hydrocarbons and air.

Product: High purity ammonia.

Description: The steam methane reforming process produces ammonia by steam reforming natural or refinery gas under pressure, followed by carbon monoxide shift, purification of raw synthesis gas, and ammonia synthesis.

In the process, saturated and unsaturated hydrocarbons are decomposed by steam according to the basic equation:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

Feed streams high in olefins or sulfur require pretreatment.

The primary reformer converts about 70 percent of a natural gas feed into raw synthesis gas, in the presence of steam using a nickel catalyst.

In the secondary reformer, air is introduced to supply the nitrogen required for ammonia. The heat of combustion of the partially reformed gas supplies the energy to reform the remainder of the gas after reacting with the oxygen in the air.

High pressure reforming conserves 30-40 percent in compressor horsepower over usual practices giving low pressure synthesis gases.

Next, the mixture is quenched and sent to the shift converter. Here CO is converted to CO_2 and H_2. When heat is still available after satisfying the water requirement for the shift reaction, a waste-heat boiler may be installed.

Shift reactor effluent, after heat recovery, is cooled and compressed, then goes to the gas purification section. CO_2 is removed from the synthesis gas in a regenerative MEA (monoethanolamine) or other standard recovery system.

After CO_2 removal, CO traces left in the gas stream are removed by scrubbing with a regenerative cuprous ammonium acetate solution. Flowsheets using methanation rather than copper solution for final purification are also available.

The resulting pure synthesis gas passes to the oil separator, is mixed with a recycle stream, cooled with ammonia refrigeration, and goes to the secondary separator where anhydrous ammonia (contained in the recycle stream) drops out.

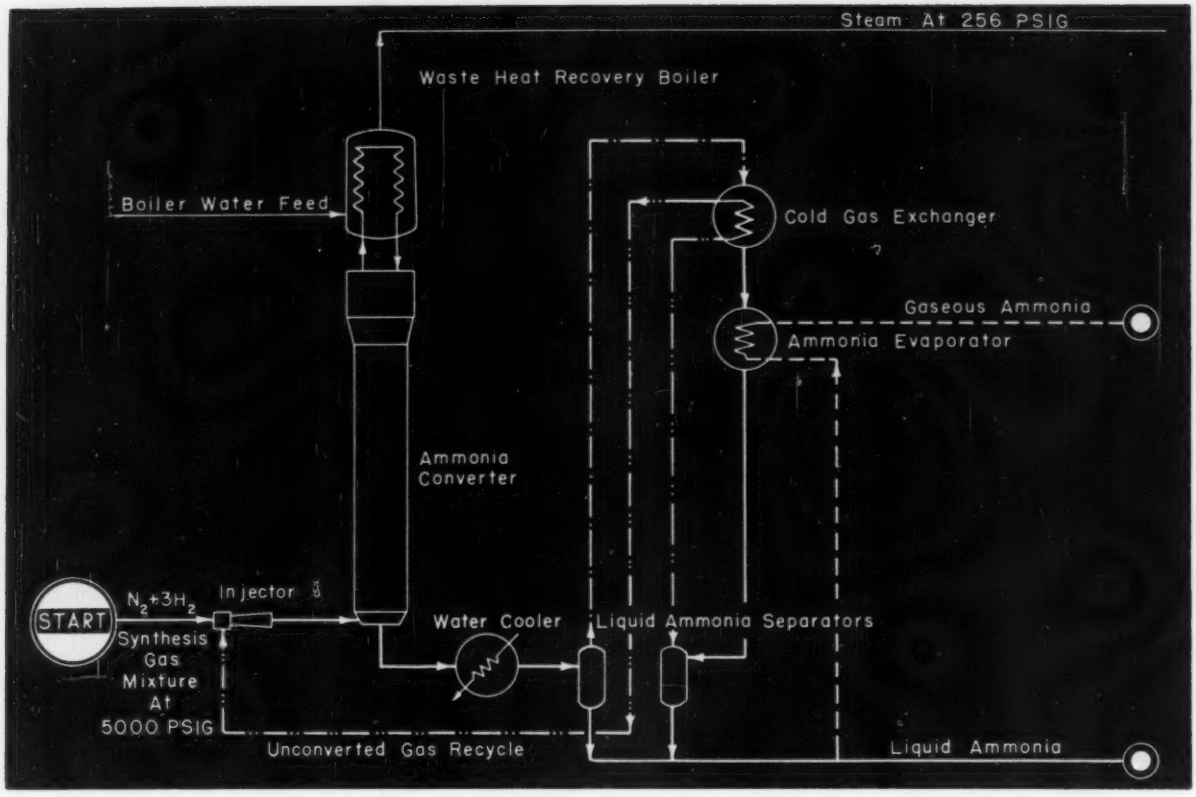
Synthesis gas is then passed through heat exchange and charged to the catalytic ammonia converter. Product gas from the converter is cooled and exchanged against converter feed gas.

Anhydrous liquid ammonia then separates out in the primary separator and, after further cooling, goes to the anhydrous ammonia product flash drum.

Operating Conditions: The feed to the reforming section is normally in the order of 300 psig. The pressure, however, is not fixed and may be varied to provide optimum design for specific local conditions. Temperatures in primary and secondary reformers are 1,400-1,800° F., while shift reaction temperatures are 700-850° F.

Ammonia synthesis is normally at 4,700 psig. The "quench-type" ammonia converter was developed by Kellogg. Temperature is accurately and flexibly controlled inside the catalyst mass to allow a catalyst basket temperature gradient giving a maximum yield of ammonia per pass, regardless of production rate.

Commercial Installations: This process is in production at eight plants with three more in construction. Total ammonia production is rated at over 2,400 tons per day. Additional installations of gasification and purification sections are rated at more than 160 MM SCFD of hydrogen and synthesis gas.



Ammonia— MONTECATINI

Application: Synthesis of ammonia by the Fauser-Montecatini processing technique.

Charge: It is essential to have a pure $N_2 + 3H_2$ synthesis gas mixture, compressed at about 5000 psig. Hydrogen contained in said mixture can be obtained by several methods and should be chosen according to the most favorable local conditions.

Product: Pure ammonia, partially available in the liquid form and partially in gaseous form. High-pressure steam is also obtained.

Description: Fresh synthesis gas mixture, before entering the converter, acts as a mechanical compelling medium for recycling the unreacted gases in a special, highly efficient injector. The converter, designed according to the up-to-date Fauser-Montecatini patented type, operates at a pressure of 4,260 psig and is equipped with a highly effective system for recovering the reaction heat.

The temperature of the different catalyst sections can be carefully controlled so as to obtain from the catalyst itself the best performance, thus increasing conversion efficiency and preventing dangerous super-heating.

The catalyst temperature control is achieved by circulating distilled water in a set of various heat exchangers placed at different levels in the catalytic mass. The waste heat recovery produces steam having the remarkable pressure of 250 psig.

As a result of such careful temperature control, gases leaving the converter have an average ammonia content of 20 percent. This is exceptionally high considering the rather low synthesis pressure.

Ammonia is condensed down at approx. —5° F in three stages: first in a water cooler, then in a cold gas exchanger and finally in an ammonia evaporating cooler.

The condensed ammonia is removed from the cycle and expanded in a let down tank. A fraction of the ammonia collected in this tank feeds the ammonia cooler where it vaporizes at about 30 psig giving the required amount of refrigeration.

After removal of the condensed ammonia the unreacted cold gases flow through the exchanger and are then recycled to the converter by means of the injector.

Several main advantages are offered by this improved process and can be summarized as follows:

The synthesis pressure chosen for this process permits safe and efficient operation of the unit together with low maintenance and operative costs.

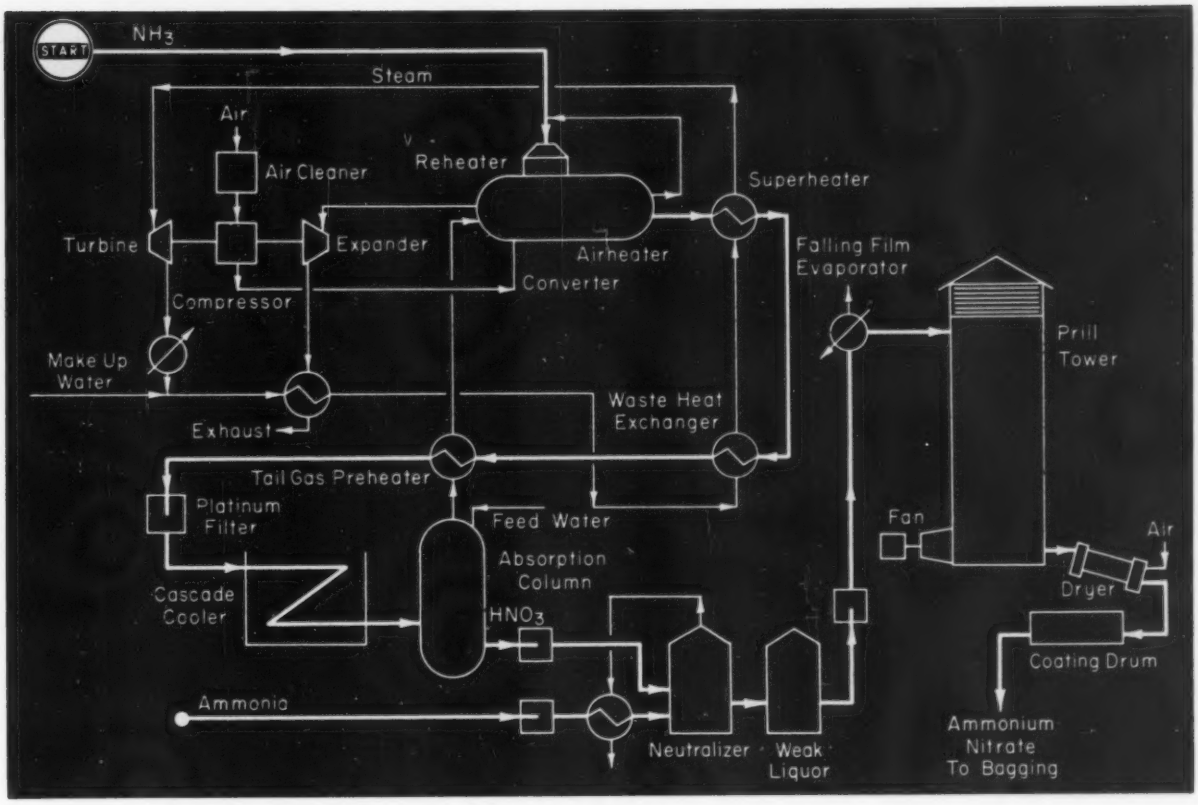
The temperature control in the catalyst layers permits high conversion, long catalyst life and makes possible the recovery of 0.85 ton of steam per ton of ammonia produced. This is an important economic factor.

The high efficiency of the injector adopted offers, in comparison with a mechanical circulator, several advantages including low cost, no maintenance, no oil entrainments (this means best operating conditions for the catalyst), power consumption comparable to that of mechanical circulators.

Operating Conditions: The main operative conditions are given in the above description. The temperature in the converter is kept at about 900° F.

Yields: For the production of 1,000 kg of ammonia, 2,750 N cu. meters of N_2+3H_2 synthesis gas mixture, compressed at 5,000 psig are required. For the same amount of produced ammonia, 850 kg of high-pressure steam are recovered.

Commercial Installations: 63 ammonia plants have been erected in 20 countries throughout the world, utilizing the Fauser-Montecatini process and accounting for more than 2,700,000 metric tons per year of ammonia capacity.



Ammonium Nitrate and Nitric Acid— THE CHEMICAL & INDUSTRIAL CORP.

Application: A process for manufacturing nitric acid and fertilizer grade ammonium nitrate.

Charge: Anhydrous liquid ammonia.

Product: 55 to 60 percent nitric acid and prilled ammonium nitrate with minimum nitrogen content of 33.5 weight percent.

Description: First, ammonia is oxidazed with air to produce oxides of nitrogen which are then absorbed in water to form nitric acid. The reactions may be written as follows:

$$4\ NH_3 + 5\ O_2 = 4\ NO + 6\ H_2O$$
$$2\ NO + O_2 = 2\ NO_2$$
$$3\ NO_2 + H_2O = 2\ HNO_3 + NO$$

Amonium nitrate is then formed by the reaction of nitric acid with ammonia as follows:

$$NH_3 + HNO_3 = NH_4NO_3$$

The necessary air is supplied by a steam turbine driven centrifugal compressor taking suction through an air filter. An expander operating on heated tail gas is used to recover the potential energy in the waste gas from the process. Compressed air is delivered to the air heater and heated to the proper temperature for combustion of ammonia. Anhydrous liquid ammonia is vaporized and superheated and fed into the mixer with the air stream from the air heater.

The mixture of heated air and ammonia enters the converter and burns on the platinum-rhodium catalyst. The oxidation mixture leaves through exchangers for heat recovery and the production of steam. A glass wool filter in the combustion gas stream collects the finely-divided platinum from the catalyst. Cooled gases are recovered in the absorption tower as nitric acid. Once started, the nitric acid plant is self-sustaining, requiring no outside power or steam.

Ammonia, vaporized by steam from the neutralizer, is sparged into the neutralizer along with nitric acid. The heat of neturalization evaporates part of the water and gives a solution of 83 percent ammonium nitrate.

Final avaporation to above 99 percent is done in a falling film evapórator located at the top of a low prilling tower. The resultant melt flows through spray nozzles and downward through the tower. Air is drawn upward by fans at the top of the tower. The melt is cooled enough to solidify, forming round pellets or prills of the desired range of sizes.

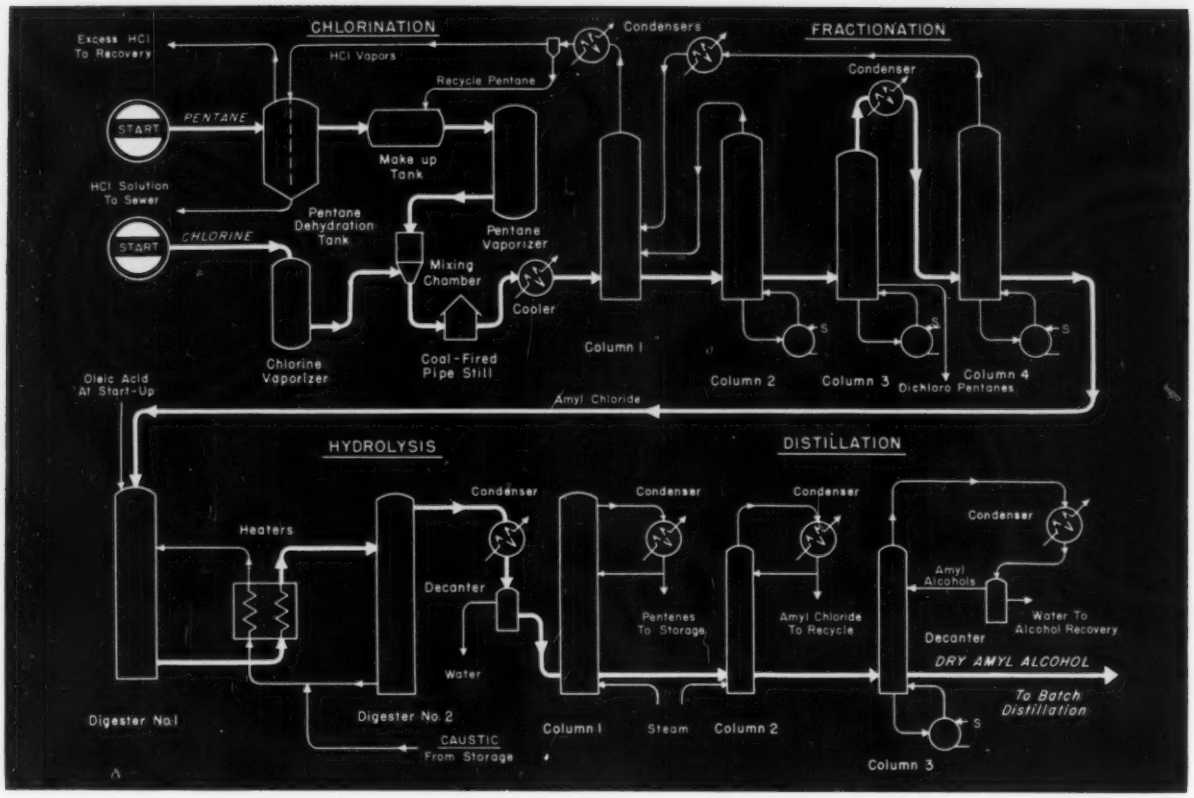
The prills are removed from the bottom of the tower and fed to a rotary cooler. Fines from the cooler are collected in a wet cyclone. The solution is eventually returned to the neutralizer.

After cooling, the prills are screened to size and the over- and under-size sent to a sump and returned to the neutralizer. Intermediate or product size prills are dusted with a coating of diatomaceous earth and sent to bagging.

Yields: The over-all yield of ammonia to ammonium nitrate is about 93 percent. This amounts to about 2.25 tons fertilizer per ton ammonia feed.

Commercial Installations: California Chemical Co., Ketona Chemical Corp., Cubana del Nitrogen, S.A., Mtanza, Cuba, and Fertilizantes del Istmo, S.A., Minatitlan, Mexico.

References: Industrial and Engineering Chemistry, Vo.. 23, p 860 (1931); Encyclopedia of Chem. Tech., Vol. 9, 333-5 (1952); Industrial & Engineering Chemistry, Vol. 45, No. 3, p 496 March (1953).



Amyl Alcohol—PENNSALT CHEMICALS CORPORATION

Application: Continuous process for the manufacture of amyl alcohols.

Charge: Pentane, chlorine, caustic soda.

Product. Various grades of mixed amyl alcohols, including primary, secondary, and tertiary isomers.

Description: Pentane is dehydrated by contacting with anhydrous hydrogen chloride, which is a by-product of the chlorination step. The anhydrous pentane and chlorine are vaporized separately, and then mixed in such proportions that the mixture is not in the explosive range. This mixture, at a temperature of about 120° C. then goes to a pipe still where the chlorination reaction takes place. The reactants leave the pipe still at about 300° C. and are immediately sent to a cooler to suppress the formation of dichloropentanes.

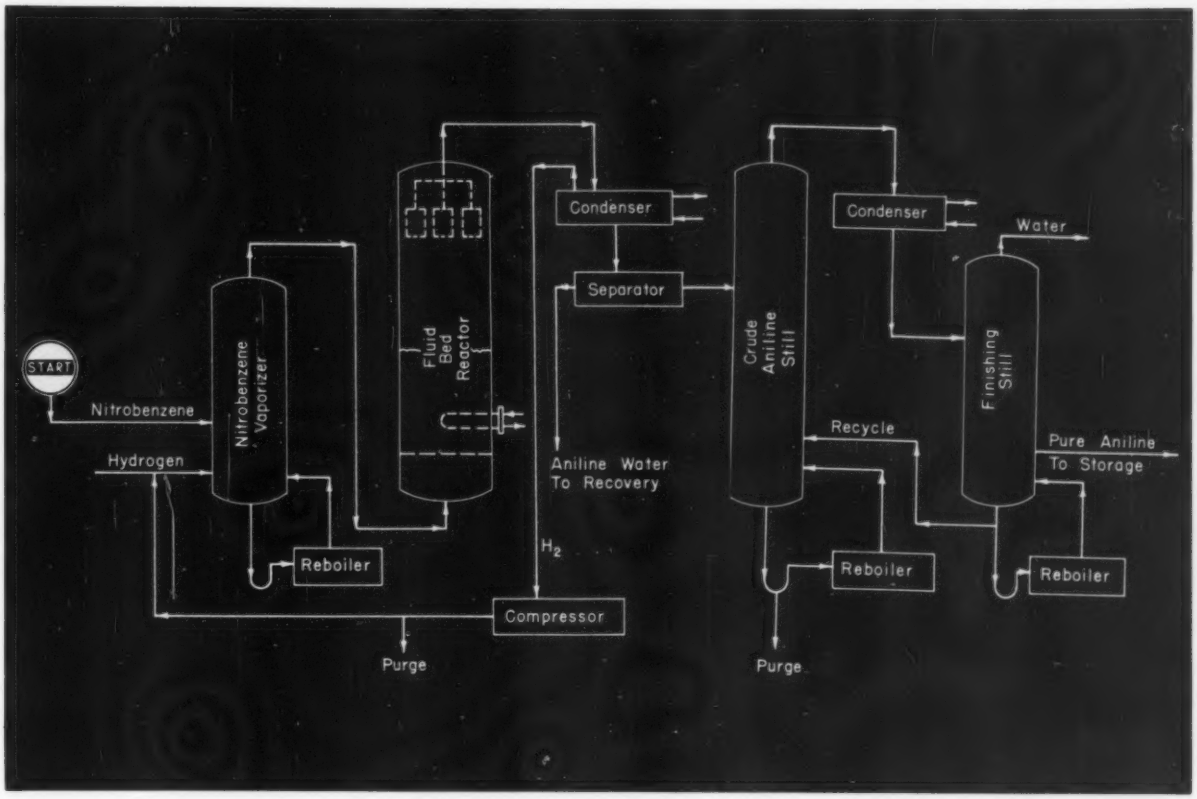
From the cooler the reaction mixture enters a fractionating column in which hydrogen chloride and pentane are removed overhead. The pentane is condensed and returned to the make-up tank. The hydrogen chloride is sent to the pentane dehydration tank where part of it reacts with the water in the pentane to form hydrochloric acid; the acid separates from the pentane and is periodically drained off to the sewer. The unreacted hydrogen chloride passes from the pentane dehydration tank to the recovery unit, where it is dissolved in water to form a commercial grade of hydrochloric acid.

The bottoms from the first column, consisting of amyl chloride, dichlorides, and some pentane, go to a second column, where the pentane is taken off overhead and recycled to the first column. The bottoms from the second column are sent to a third column where amyl chloride is taken off overhead, and dichloropentanes are removed as the bottom product. The amyl chloride then goes to a fourth column in which residual amounts of pentane are removed, and recycled to the first column.

The amyl chloride (a mixture of the primary, secondary, and tertiary isomers) is scrubbed with caustic to remove traces of hydrogen chloride, and is then fed to a digestor in which it is hydrolyzed to form amyl alcohol. Caustic soda is used as the hydrolyzing agent, and oleic acid as a catalyst. The mixture goes to a second digestor from which crude amyl alcohols are removed as a top product. Brine is formed as a byproduct of the hydrolysis reaction, and is removed from the bottom of the second digestor.

The crude alcohol is condensed, and the water fraction removed by decantation. It then goes through a series of three columns in which amylenes (a byproduct of the hydrolysis reaction), amyl chloride, and water are removed. The amylenes are used in the production of amylphenols in another process, and the amyl chloride is recycled to the digestors. Finally, the mixture of amyl alcohols is charged to a batch still where the various grades and isomers are separated by fractionation through a bubble cap column.

Reference: Petroleum Refiner, Sept.'53,p207. *Industrial & Engineering Chemistry,* Vol.42,2388 (1950).



Aniline— AMERICAN CYANAMID COMPANY

Application: A vapor-phase fluid-bed catalytic process for reduction of nitrobenzene to aniline.

Charge: Nitrobenzene containing less than 10 ppm nitrothiophene and hydrogen.

Product: Aniline—Freezing point —6.2° C minimum.

Description: Mononitrobenzene prepared from benzene by standard nitration processes, is fed to a lower tray of a bubble-tray tower. Heat supplied by a reboiler vaporizes the nitrobenzene into a stream of hydrogen which is fed up the tower. The mixture of nitrobenzene and hydrogen containing approximately three times the theoretical amount of hydrogen required for the reduction is passed through a porous distributor plate into a reduction chamber containing a fluidized bed of copper catalyst. Excess heat of reaction is removed by circulation of a heat-transfer liquid through tube bundles suspended in the catalyst bed. The upper portion of the reactor, essentially empty, acts as a disengaging zone and permits a major portion of the catalyst particles entrained in the gas stream to fall back into the catalyst bed. The exit gases are filtered free of catalyst on porous stainless steel filters.

The filtered gases are cooled in a condenser to separate aniline and water from the excess hydrogen which is recycled except for a small purge. The aniline is separated from water in a decanter. The crude aniline containing less than 0.5 percent unreacted nitrobenzene and about 5 percent water is distilled to remove high boilers. The water and aniline which pass overhead are condensed and redistilled in a finishing tower.

The catalyst is prepared by the adsorption of cuprammonium nitrate on silica hydrogel followed by spray drying to yield a fluidizable powder with a particle diameter of 20 to 150 microns. The catalyst is activated in place in the converter by reduction with hydrogen at a temperature of about 250° C. Careful control of the quality of nitrobenzene will give long active life catalyst (1,500 units of aniline per unit of catalyst) before regeneration is required. Regeneration may be accomplished in place by stopping the nitrobenzene feed, flushing the system with inert gas and passing air through the catalyst at 250° C — 350° C to burn off organic deposits.

The reaction is as follows:

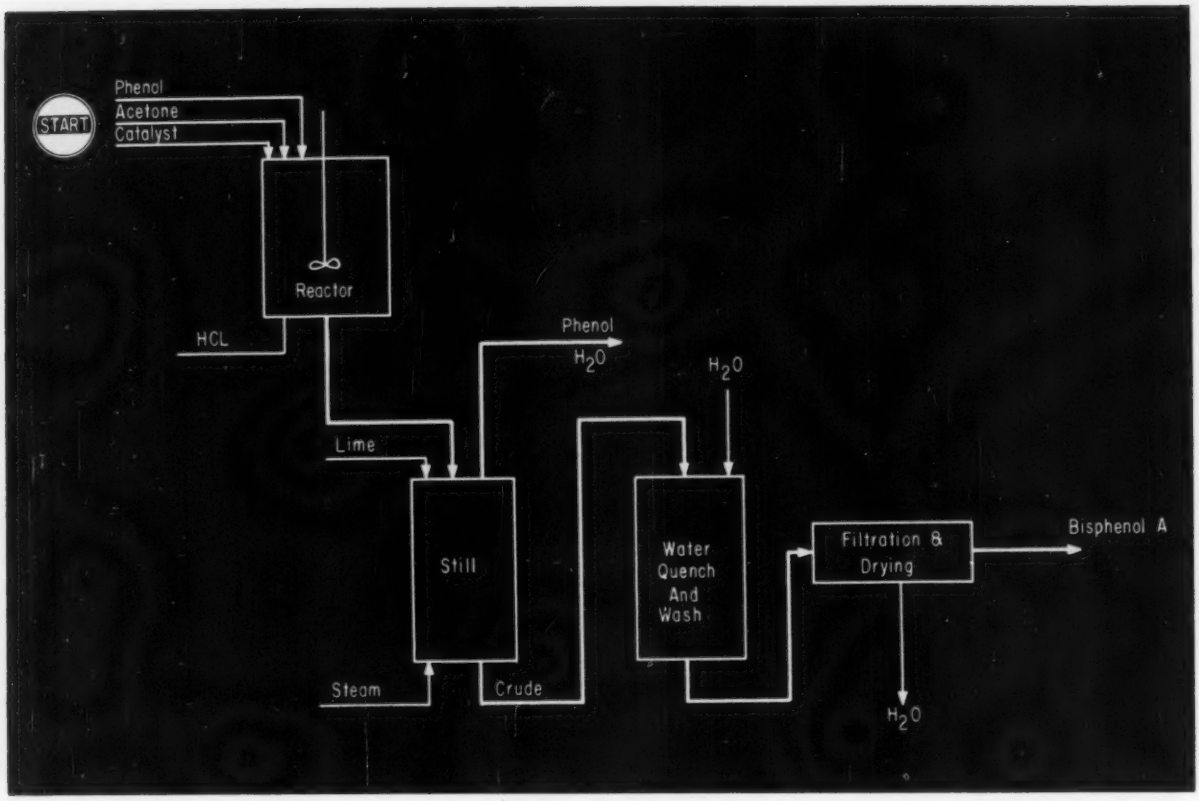
$$C_6H_5NO_2 + 3H_2 = C_6H_5NH_2 + 2H_2O$$

Operating Conditions: The reduction is carried out at 270° C and 20 psig.

Yield: The yield of aniline from nitrobenzene is approximately 98 percent of theory.

Commercial Installation: American Cyanamid Company, Willow Island, W. Va.

References: O. C. Karkalits, Jr., C. M. Vanderwaart and F. H. Megson (to American Cyanamid Company) U.S. 2,891,094.



Bisphenol A

Application: This is a process for the production of Bisphenol A (4,4′—isopropylidenediphenol).

Charge: Phenol, acetone, hydrochloric acid.

Product: Bisphenol A suitable for production of epoxy and polycarbonate resins.

Description: Phenol and acetone in a molar ratio of 3:1 or 4:1 are charged to an acid-resistant stirred reactor. Glass-lined equipment is used ordinarily. A sulfur-containing catalyst is added, then dry hydrogen chloride gas is bubbled into the reaction mass. The temperature is maintained at 30°-40° C for 8-12 hours. The product crystallizes from the reaction mixture to form a slurry.

At the end of the reaction, the mixture is washed with water and just enough lime is added to neutralize the free acid. Vacuum and heat are applied to the reaction kettle and water and phenol distilled separately from the mixture. The batch is finished by blowing the molten product with steam under vacuum at 150° C to remove the odor of the sulfur-containing catalyst.

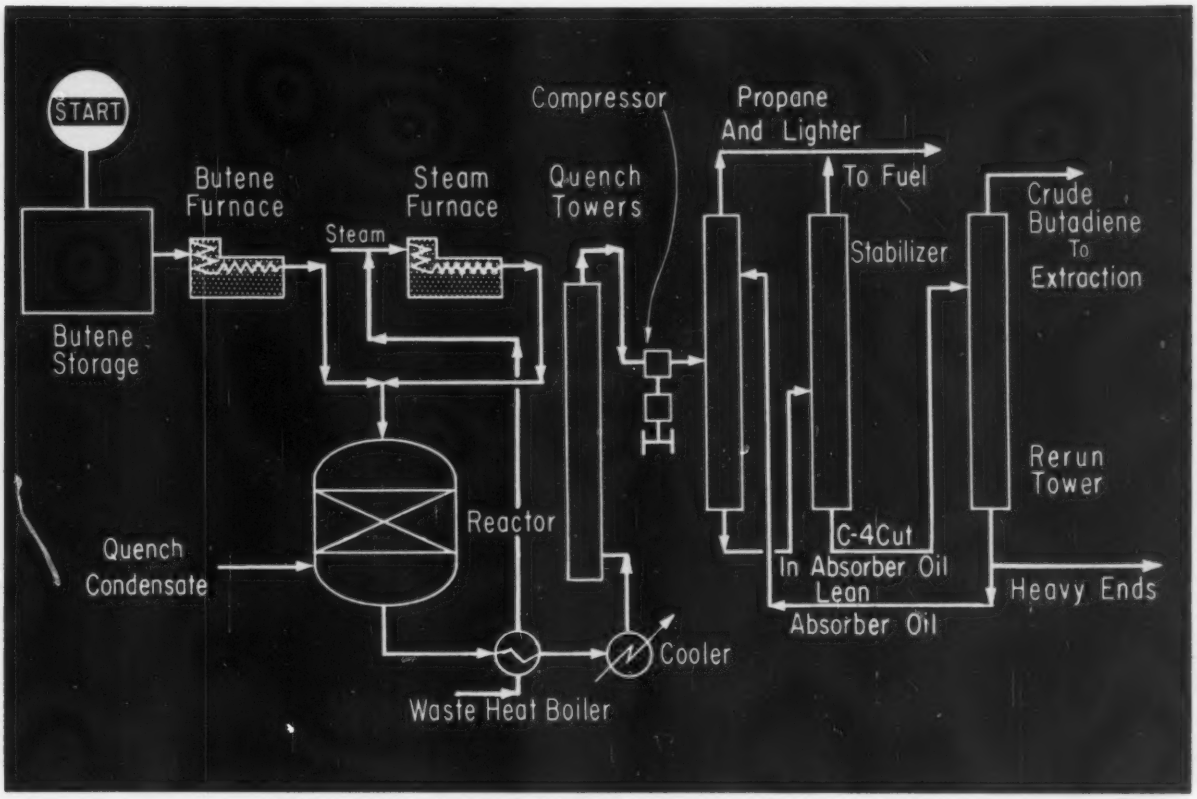
The molten product is quenched in a large volume of water, filtered, and dried. It is a light tan powder, which may be further purified by recrystallization from solvents.

Operating Conditions: The main reaction is run near room temperature, 30°-40° C, depending on the catalyst used. Water is removed from the product at about 60° C. and the final distillation of unreacted phenol and the steam deodorization are carried out near 150° C. The catalysts used may be any ionizable organic sulfur compound, including mercaptocarboxylic acids, mercaptans, and hydrogen sulfide.

Yields: Yields of 98 percent based on acetone are reported.

Commercial Installations: This process or similar ones are used by Dow Chemical Company, Midland, Mich.; Monsanto Chemical Co., St. Louis, Mo.; and Shell Chemical Co., Houston.

References: R. P. Perkins (to Dow) U.S. 2,191,831 (Feb. 27, 1940); R. P. Perkins and Fred Bryner (to Dow U.S. 2,359,242 (Sept. 26, 1944); W. L. Stoesser and E. Sommerfield (to Dow) U.S. 2,623,908 (Dec. 30, 1952); Geo. T. Wilkinson (to Shell Development Co.) U.S. 2,775,620 (Dec. 25, 1956).



Butadiene from Butenes— ESSO RESEARCH AND ENGINEERING COMPANY

Application: A process for the catalytic dehydrogenation of normal butenes to butadiene-1,3.

Charge: A C_4 hydrocarbon stream containing about 80 weight percent n-butenes.

Product: A crude butadiene stream from which high-purity butadiene can be extracted.

Description: The feed is preheated to about 1000° F in the hydrocarbon superheater. The hot gases are then mixed with superheated steam and the mixture is passed through the fixed-bed catalyst.

The low partial pressures necessary for the dehydrogenation of the butenes to butadiene by the catalyst are obtained by the use of this steam. Carbon deposited on the catalyst is removed by a "water gas reaction" with steam, partially during the dehydrogenation and partially during the regeneration cycle.

The hot gases leaving the reactor go through steam generators where they are cooled and where some of the steam for the process is generated. The hot reactor effluent is further cooled in an oil quench tower and a water quench tower. Water condensed from the effluent after compression is stripped of any volatile hydrocarbon in a water stripping tower and is then discharged to a blowdown system.

After compression and cooling, the effluent enters a condensate separator. The gases from the separator are fed to the absorber where the C_4 hydrocarbons are absorbed in a light naphtha which is then recycled to the oil quench tower. The condensate from the separator, containing the unstabilized C_4 cut, is fed to the stabilizer where the lighter components are removed overhead.

The bottoms stream from the stabilizer is fed to the rerun tower where the C_5 and heavier components are removed as bottoms. The overhead stream is the crude butadiene product.

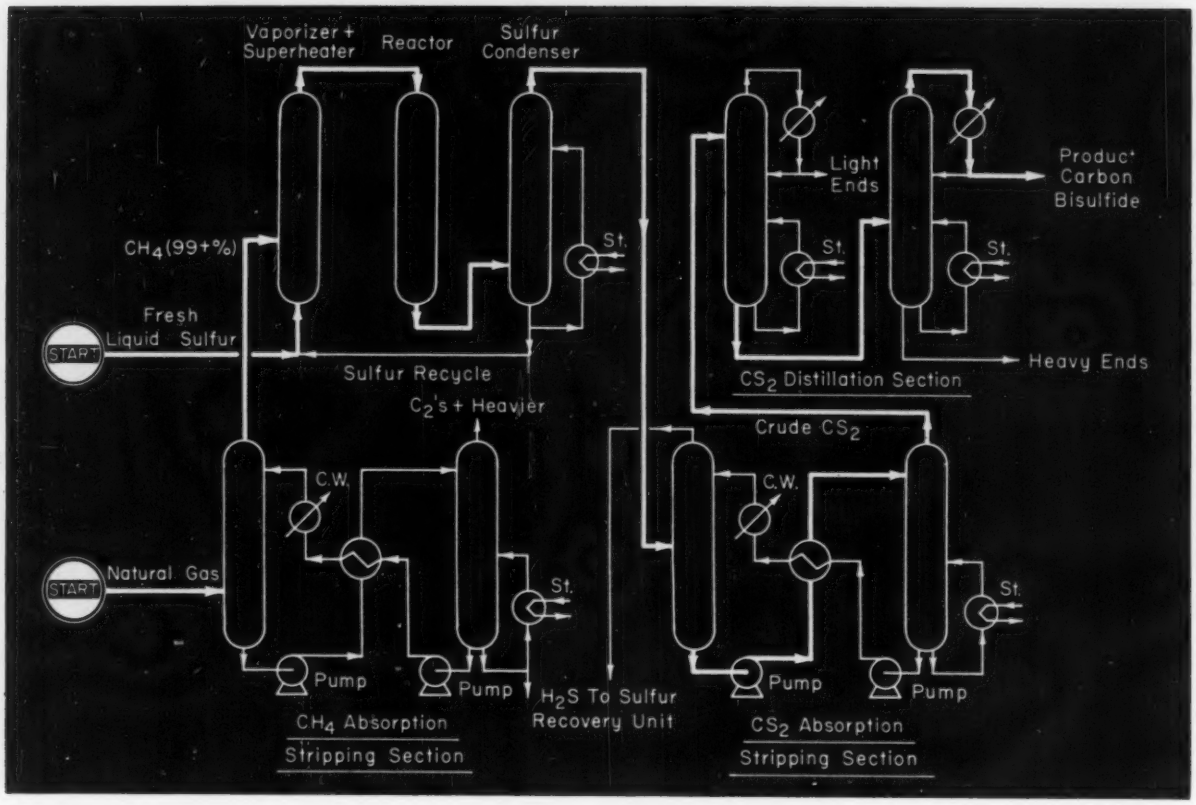
Operating Conditions: The principal operating conditions are:

Space velocity, V/H/V (Volume of n-butene as gas at standard conditions per hour per volume of catalyst)	125-225
Pressure Above Bed, psig	7-11
Pressure Below Bed, psig	2-4
Partial pressure, mm Hg. (at reactor inlet)	60-80
Steam/Butene, Gas Volume Ratio	14-18
Temperature, ° F.	1150-1250

Yields: Typical once-through yields* are as follows:

	Feed Weight Percent	Products Weight Percent
Normal Butenes	80.0	60.0
Butadiene	2.0	16.4
Other C_4's	18.0	16.0
Polymer	....	1.0
Fuel Gas and Coke	....	6.6

* Yields and operating conditions will depend upon the catalyst used.



Carbon Bisulfide — C. M. THACKER

Application: A process for the manufacture of carbon bisulfide.

Charge: Sulfur, liquid or solid; and natural gas, predominantly methane.

Product: Liquid sulfur is combined with recycle sulfur in a suitably insulated tank held at 250-270° F by steam coils. The liquid is transferred continuously to a furnace provided with high chrome steel coils where the sulfur is vaporized, mixed with methane of high purity (99+ percent) and the mixed gases are superheated to 1200 to 1300° F.

Methane of the required purity is extracted from natural gas by absorption of its C_2's and heavier components in a light absorption oil, such as kerosine.

The superheated vapors, methane and sulfur, are passed down through a reactor where carbon bisulfide is formed according to the reaction

$$CH_4 + 4\,S\ (Vapors) = CS_2 + 2\,H_2S$$

The reactor is a vertical high chrome steel vessel filled with a synthetic or artificial clay catalyst and the reactor is operated adiabatically. Although earlier units operated at less drastic conditions, modern units operate at temperatures of about 1250° F; 15-25 psig; and at vapor hourly space velocities of about 600. The proportions of sulfur to methane used are 5-10 percent in excess of the stoichiometric requirements. Methane conversions are in excess of 85 percent during passage through the reactor which eliminates the necessity of recycling methane.

The reaction yields approach the theoretical very closely. By-products in the crude carbon disulfide include light mercaptans and heavy di- and poly-sulfides. The reactants are cooled and unreacted sulfur recovered by scrubbing with liquid sulfur. After sulfur removal, the gases are fed to an absorption column in which carbon bisulfide is removed by a selective, mineral oil-type solvent. The rich oil is pumped to a stripper where the carbon bisulfide is removed and sent to the distillation section. The off-gas from the absorber contains over 90 percent hydrogen sulfide and passes to a sulfur recovery unit where by controlled oxidation in the presence of clay type catalysts hydrogen sulfide is converted to sulfur.

The stripped carbon disulfide is purified in two successive distillations, with the final product being taken overhead from the second column. The distillation columns are of steel construction and may, or may not utilize refrigerated overhead condensers, depending on local conditions.

The stripped carbon bisulfide product is stored and shipped in steel tank cars or steel drums. A blanket of water is used to minimize fire hazards.

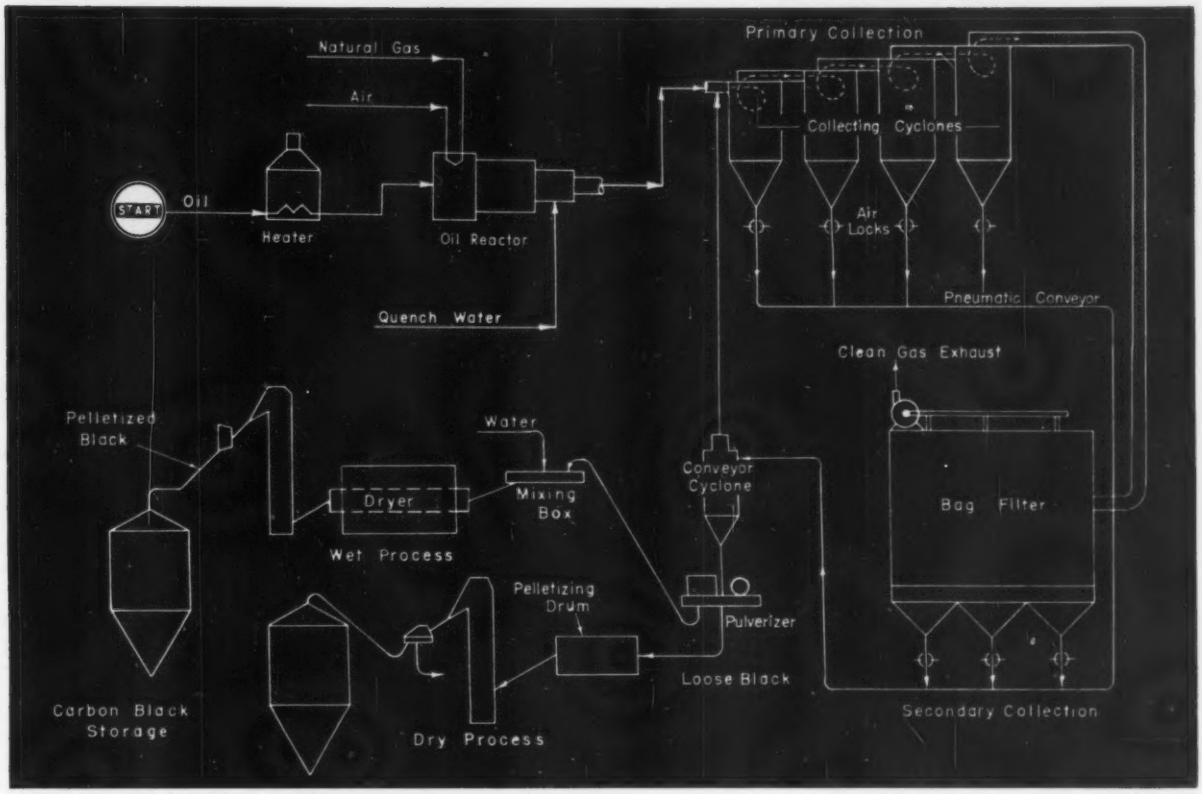
Operating Conditions: Typical conditions for the catalytic reaction of methane with sulfur in the latest and most modern plants are given in the above text. Older plants where the temperature of operation is held in the range of 1050-1150° F require more equipment; i.e., a reactor operating in stages with heating between stages and/or an amine absorption-stripping system for separating methane for recycle from hydrogen sulfide.

Yields: Typical over-all process yields—percent of theoretical:

	Modern No CH_4 Recycle	Old With CH_4 Recycle
Carbon bisulfide from methane.	85-90	92-96
Carbon bisulfide from sulfur.....	91-92	91-92

Commercial Installations: Columbia-Southern Chemical Corp., South Charleston, W. Va.; Food Machinery & Chemical Corporation, South Charleston, W. Va; Snai Viscosa, Milan, Italy; and Stauffer Chemical Company, LeMoyne, Ala. Plants under construction: Glanzstoff Courtaulds, Cologne, Germany, and Stauffer Chemical Company, Delaware City, Del.

References: Thacker & Miller, *Ind. Eng. Chem.*, 36, 182-4 (1944); U.S. 2,330,934; Folkins, Miller & Hennig—*Ind. Eng. Chem.*, 42, 2202 (1950).



Carbon Black (Oil Black)— CONTINENTAL CARBON COMPANY

Application: A process for manufacturing highly re-inforcing furnace blacks from heavy residual oils.

Charge: Heavy residual oil, natural gas, air.

Products: HAF, ISAF, and SAF carbon blacks, pelletized, bulk density 20 to 24 pounds per cubic foot.

Description: Oil is preheated in a direct-fired or molten salt type heater and atomized into a reactor in which gas and air are burned to provide the heat necessary to crack the oil. The furnace used may be one of several variations. An example is the Phillips type (Krejci, J. C. to Phillips Petroleum Company, U.S. 2,526,700, August 21, 1951) now being used under a licensing agreement. Air for the reactor is furnished by centrifugal blowers. The temperature in the oil reactor is maintained in the range of from 2,500° to 2,600° F, by controlling the oil flow rate. The oil is cracked to carbon and hydrogen with side reactions producing carbon dioxide, carbon monoxide, and water. Trace amounts of acetylene and methane are also produced.

In the quench section of the reactor, direct water sprays cool the carbon laden gases to about 1000° F. The mixture is further air cooled in a long duct to about 550° F, before entering a header leading to the collection system.

The cooled reaction mixture passes from the header into a series of four cyclones which remove 70 to 80 percent of the black then into the final cleaning step in which silicone coated glass fabric bags remove essentially 100 percent of the black. Alternatively, an electrostatic precipitator, cyclone, wet-scrubber combination may be used with the resultant slurry re-cycled to the quench for recovery.

Carbon black is continually discharged from the collection equipment by rotary valves and picked up by a pneumatic conveyor. The black is collected in a smaller diameter collecting cyclone and discharged through a high speed hammer mill to break up and disperse the very small quantities of hard agglomerates that may be present.

The pulverized carbon black is then conveyed by screw conveyor to the pelletizing system. Two methods of pelletizing are used, dry process and wet process. The dry process consists of a continuous feed of loose black into a rotating drum and a continuous discharge of pellets. In the wet process, the black is mixed with about an equal weight of water, the mixture agitated and the resultant pellets dried.

Pelletized black is shipped in bulk hopper cars or automatically packed in 50 pound three ply kraft paper valve type bags.

Operating Conditions: Reactor design and flow rates are extremely critical in determining the quality and type of black.

Yields: The process yields up to 60 percent of the carbon content of the oil feed depending on the charge stock and the grade of black desired as the finished product.

Commercial Installations: All producers use variations of the process. Examples are Continental Carbon Company at Ponca City, Oklahoma; and Westlake, Louisiana; Phillips Chemical Company, Borger, Texas.

References: PETROLEUM REFINER, Nov. '57,p227; *Industrial & Engineering Chemistry,* April '52,p685-694.

Chloromethanes— MONTECATINI

Application: A process for the manufacture of the four chlorosubstituted derivatives of methane by direct thermal chlorination of natural gas.

Charge: Natural gas and dry gaseous chlorine.

Products: Methyl chloride, methylene chloride, chloroform, carbon tetrachloride.

Description: The Montecatini process for thermal chlorination of methane allows different cycles according to the desired partition of products among the various chloromethanes and according to the form in which byproduct hydrogen chloride is to be recovered (either as a 30-32 percent commercial aqueous solution or in dry, gaseous form).

In any case, the basic process includes several common steps; some of them include different alternatives which will be mentioned below.

Chlorination. Chlorination of methane is an exothermic chain-reaction, yielding 24,000 kcal/kmol of reacted chlorine. The industrial reaction is carried out in an adiabatically operated furnace in which the evolved reaction heat is recovered for pre-heating fresh gas feed. Temperature is kept between 370° and 410° C according to the selected cycle (see below); in this way total conversion of chlorine to chlorinated products is achieved. Fresh gas feed is preheated at about 280° C before entering the furnace. The methane/chlorine ratio in the gas feed is the factor which pre-establishes the reaction conditions. Thus in order to obtain, as main products, a mixture of light chlorinated compounds (i.e. CH_3Cl, CH_2Cl_2 and $CHCl_3$) a CH_4/Cl_2 ratio of at least 3,5-4 must be used when mixing fresh gas feed components. When, on the contrary, carbon tetrachloride is the desired main product, the reactants ratio must be kept between 0.5 and 0.8. However, chlorine gas must be diluted in the feed gas stream in order to avoid explosion hazards. In the Montecatini process, the double problem of pre-heating the reactants and suitably diluting chlorine in the gas feed mixture has been solved by means of two recycle steps; the first of them is represented by recycling a major portion (75-80 percent) of the hot gases leaving the furnace (the so-called "small recycle") and blending the same with cold gases, containing make up fresh feed plus uncondensed gases available after the condensation step (the so-called "big recycle").

Different Cycles: By using a single chlorination cycle it is not always possible to obtain a balanced amount of the four chlorinated products according to market requirements. Thus it is sometimes necessary to use two different cycles, one of which mainly yields light products while the second gives mainly carbon tetrachloride. In the first case methane in excess is sufficient for dilution purposes and temperature control is easily obtained. (The so-called "methane cycle"). In the second case, an inert gas must be used and to this aim nitrogen has been selected as the most suitable. (The so-called "nitrogen cycle"). Since the composition of reacted and unconverted gases is quite different in the two cases, separate furnaces and subsequent intermediate equipment must be used. The final rectification step is shared in common by both cycles.

Cooling and Hydrogen Chloride Recovery. Reacted hot gases are cooled in a water-sprayed cooler and effluent is fed to an absorption tower in which HCl is recovered. The tower can be operated either adiabatically or isothermally. The absorbing liquid can be pure water and in this case an aqueous 32 percent HCl solution is obtained as a by-product. When, on the contrary, pure dry gaseous HCl is the desired by-product, an azeotropic mixture HCl/H_2O is circulated in the tower; from the bottom of the same, the solution is sent to a stripping tower. Here pure and dry HCl gas is obtained as the top effluent while the bottom azeotropic mixture is recycled back to the absorption step.

Neutralization. The reacted gases are subsequently scrubbed with a caustic soda solution in order to eliminate small amounts of HCl and CO_2; the latter would otherwise accumulate as an inert component in the circulating gaseous mass.

Compression. Compression is necessary in order to condensate the obtained products at a sufficiently high temperature. Pressure is established according to the desired products, but it cannot be lowered beyond a given minimum value since uncondensed gases, in the "big recycling" step are used as a propellant fluid in an ejector for recycling hot effluent gases. ("Small recycle").

Drying and Separation of Crude Product. Water must be avoided both in the chlorination and in the rectification stage. Therefore, a careful drying step is necessary. The same can be accomplished in two ways, namely before or after compression. In both cases, strong H_2SO_4 (98 percent by weight) is used as a drying medium in two successive towers. The spent acid has a final strength of about 75 percent. If drying is performed before compression, the operation is simpler; if on the other hand, drying is carried out after compression, acid consumption is about 10 times lower; therefore, this second alternative is preferable in most cases.

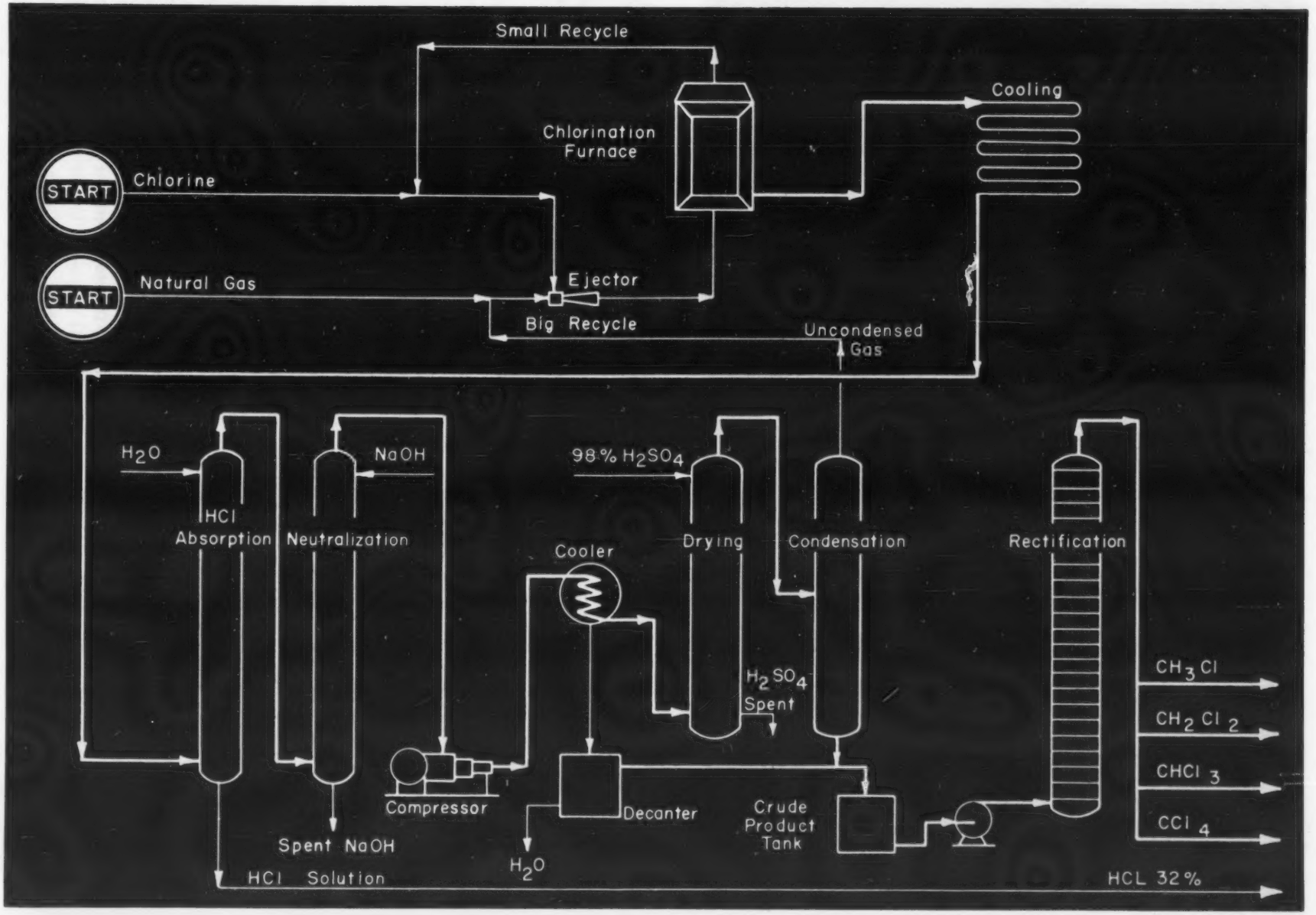
Rectification of Crude Product: This is quite a conventional step and does not present any particular difficulty. Taking into account the purity specifications usually required by market standards for chloromethanes, some care must be taken in the case of methyl-chloride (standard purity usually not lower than 99.9 percent).

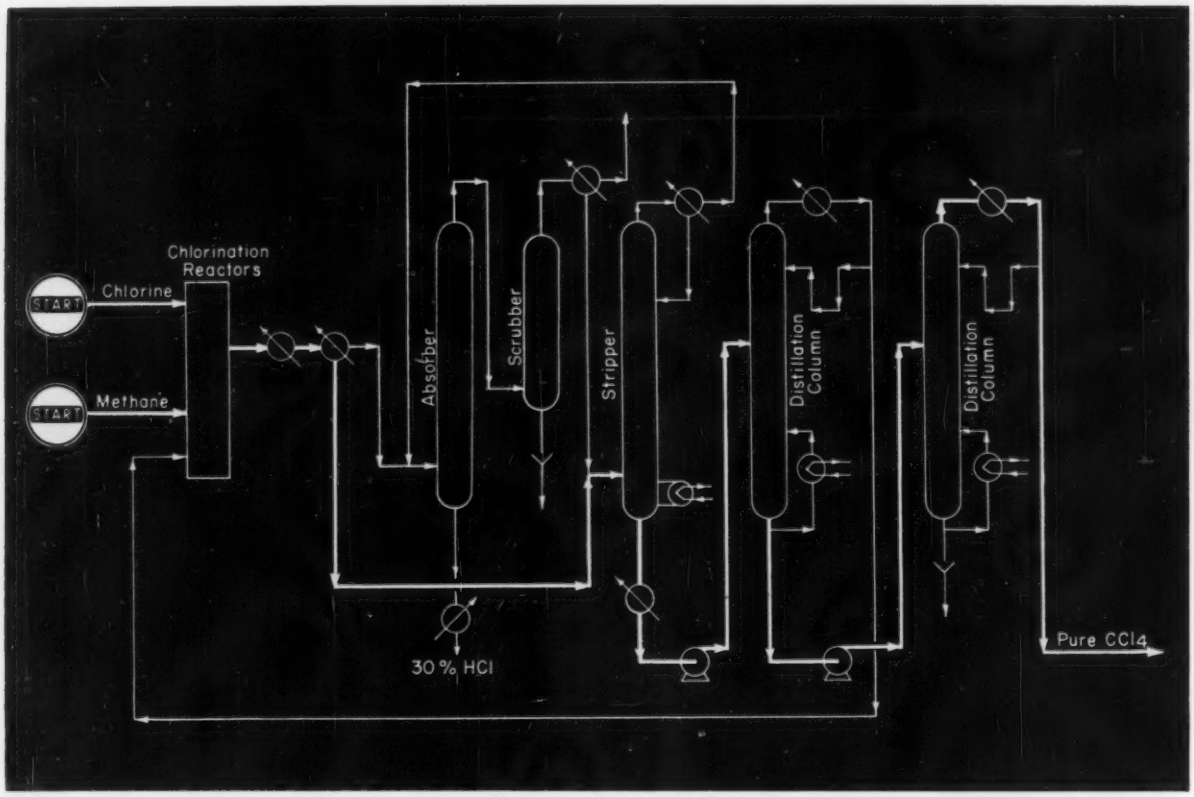
Of course the assembly of rectification towers is different according to the different cycle adopted. When the plant is composed of two cycles (the "methane" cycle and the "nitrogen" cycle: see above) the rectification step is in common.

Operating Conditions: the main operative conditions have been already mentioned in the above description. Emphasis is here given again on close temperature control. Too high temperatures foster the formation of carbon black and yields in chlorine conversion are lowered.

Yields: As already stated above, by careful selection of the operating conditions and of reactants composition, almost quantitative conversion rate of chlorine can be achieved.

Commercial Installations: A plant of the kind described has been built for Allied Chemical Corp. in the United States at Moundsville (W. Va.).


Small Recycle
Chlorination Furnace
Cooling
START
Chlorine
START
Natural Gas
Ejector
Big Recycle
Uncondensed Gas
H_2O
NaOH
98% H_2SO_4
HCl Absorption
Neutralization
Cooler
Drying
Condensation
Rectification
H_2SO_4 Spent
CH_3Cl
CH_2Cl_2
$CHCl_3$
CCl_4
Compressor
Decanter
Crude Product Tank
Spent NaOH
HCl Solution
H_2O
HCL 32%



Carbon Tetrachloride (Hoechst Process) — HOECHST-UHDE CORPORATION

Application: A process for carbon tetrachloride production by the thermal chlorination of methane.

Description: The chlorination of methane to form carbon tetrachloride takes place according to the following reaction:

$$CH_4 + 4\,Cl_2 \rightarrow CCl_4 + 4\,HCl + 89\ Kcal$$

This exothermic reaction is carried out continuously in reactors of special design. The effluent gas consists largely of carbon tetrachloride and hydrogen chloride. The HCl is absorbed in water. The raw CCl_4 is condensed and purified by distillation. The lower chlorinated methanes are obtained as overhead and may be recycled to the reaction section.

With a variation in the design of the recovery system, by-product HCl may be obtained as a gas, containing a small amount of CCl_4 and the inerts introduced with the methane and chlorine feed streams.

Raw Materials: The methane fed to the reactors must be dry and substantially free of higher hydrocarbons which reduce the yield and cause corrosion in distillation equipment. The concentration of inerts (N_2 and CO_2) should be as low as possible. The chlorine gas must be dry and substantially inert free.

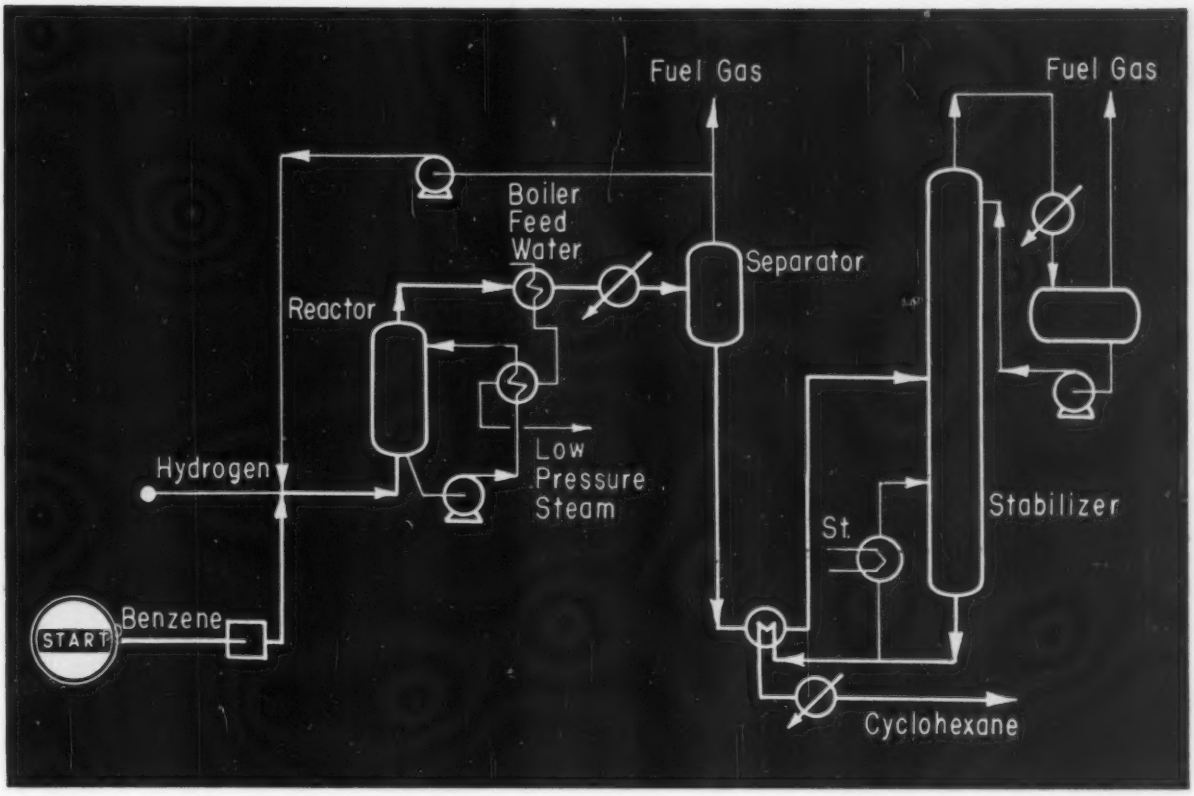
The following quantities of methane and chlorine are consumed per ton of CCl_4 produced:

Cl_2	3800 lb.
CH_4	223 lb.

These figures correspond to yields of 97 percent of theoretical based on chlorine and 93 percent based on methane.

Products: The carbon tetrachloride product is free of HCl, Cl_2, and organic impurities. The HCl is obtained as 30 percent hydrochloric acid and amounts to 1900 lb. HCl per ton of CCl_4 produced.

Commercial Development: The process was developed in a 10 T/D semi-works unit at the Hoechst plant of Farbwerke Hoechst AG in Germany. A 60 T/D commercial unit is in operation at Hoechst.



Cyclohexane — INSTITUT FRANCAIS DU PETROLE

Application: A process for the liquid-phase catalytic hydrogenation of benzene to produce high-purity cyclohexane.

Charge: Benzene and a hydrogen-rich gas.

Product: When processing high grade benzene (5.4° C solidification point), a product containing 99.8 + wt. percent cyclohexane with less than 0.1 wt. percent benzene and having a freezing point of 6.0° C is obtained. Lower purity benzene feed will lower the cyclohexane product freezing point.

Process Description: Fresh and recycle hydrogen-rich gas, together with benzene feed are introduced into the reactor where the conversion of benzene to cyclohexane is virtually complete. Agitation of the reacting phase is assured by external circulation of the liquid through a steam generator.

Reactor effluent is condensed and the liquid separated in a flash drum. Most of the flashed gas is recycled, a small amount being bled from the system to avoid light HC build up.

The liquid effluent passes to the stabilizer which removes light dissolved gases overhead.

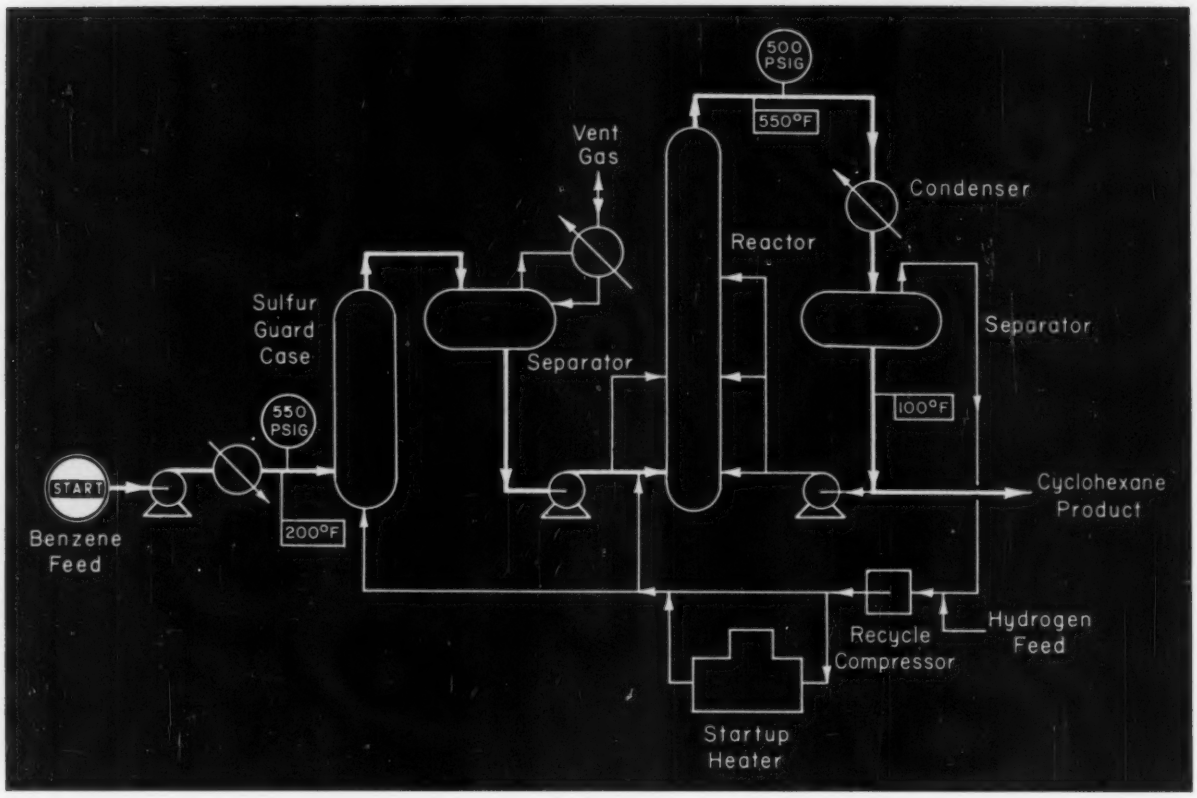
Operating Conditions: One of the features of the process is to operate in the liquid phase with consequent mildness of operating conditions resulting in minimum capital investment and reduced operating costs.

Yield: Virtually stoichiometric yields of cyclohexane from benzene are obtained.

Economics: The study presented hereunder corresponds to a 10,000 t/yr unit under French conditions and assumes a H_2 gas containing 95 percent vol. H_2 and available at 40 atm. Offsites and storage facilities are not included. Contractor's costs are included in the investment.

Investments (delivered and erected in France)	$200,000
Initial catalyst load + paid up royalty	11,000
Estimated Operating Costs	$/year
Labor (incl. sup. & adm. ovh.)	26,000
Utilities (no credit given to LP steam produced)	8,000
Catalyst & Chemicals	4,000
Maintenance	8,400
Local Taxes & Insurance (2% of investment)	4,220
Depreciation Allowance (10% of investment	21,100
Interest on loans (8% on avg. investment)	8,440
Total Operating Cost	$ 80,160/year
or 2.34¢ gal. cyclohexane	

Commercial Installations: The first commercial unit has been engineered and others are at the design stage.



Cyclohexane—KRELL & ASSOCIATES, INC.

Application: A process for catalytic hydrogenation of benzene to produce high-purity cyclohexane. Variations of the process may be used for converting toluene and higher aromatics to their respective cycloparaffins.

Charge: High-purity benzene with a relatively low sulfur content and a hydrogen-containing gas.

Product: Cyclohexane of essentially the same purity as the benzene feed.

Description of Process: The first step in the process is the removal of sulfur from the raw benzene stream by hydrogenation. Catalyst used for this reaction may be spent catalyst from the main hydrogenation reactor. If a sulfur-free feed is available, the desulfurization step may, of course, be eliminated.

After the sulfur is removed, the benzene is hydrogenated to cyclohexane in a fixed bed reactor. This reactor operates with both liquid and gas phases present. The heat of reaction is removed by heating the charge materials and by heating and vaporizing recycled cyclohexane. The overhead stream from the reactor contains cyclohexane, excess hydrogen, and a trace of benzene. Equilibrium benzene content in the product is about 0.01 percent, and equilibrium is closely approached at the space velocities employed.

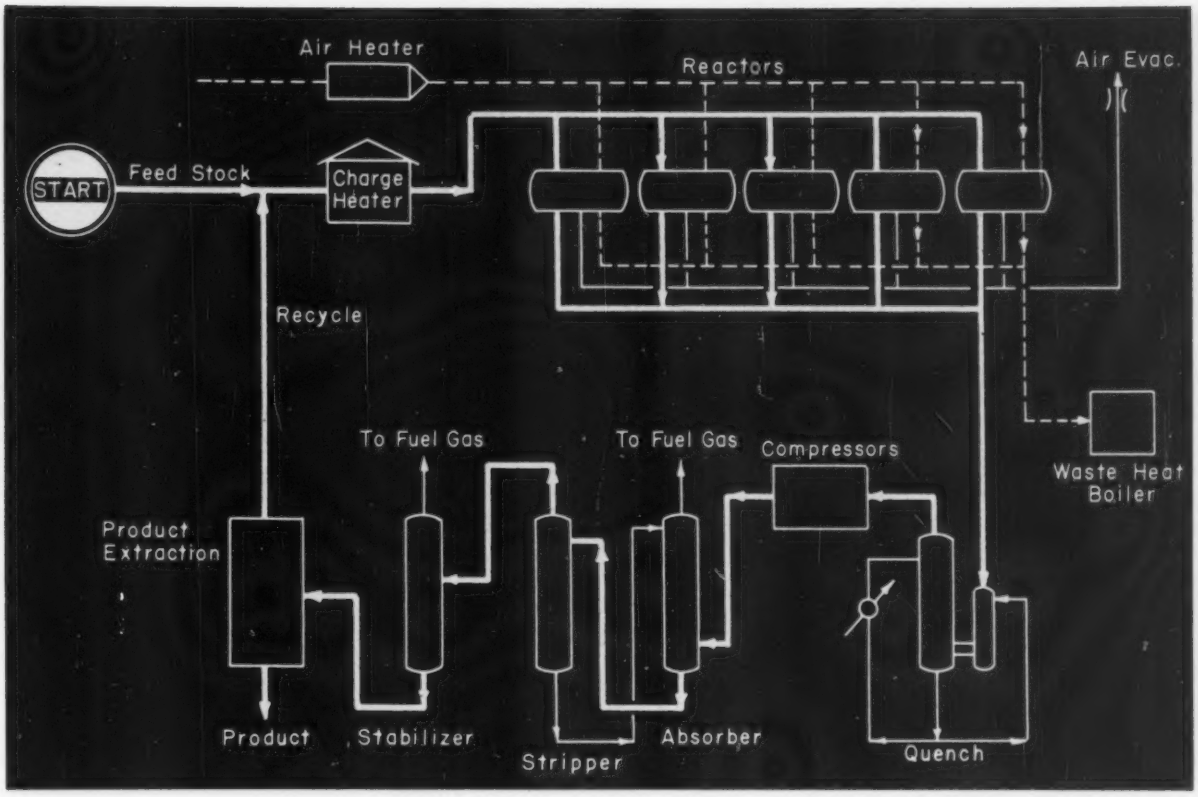
The overhead stream is cooled to condense cyclohexane, and the excess hydrogen is recycled to the reactor. Product cyclohexane is transferred to storage by the system pressure. Final product purity will depend on the purity of the charge benzene. Any saturated hydrocarbons in the feed will be essentially unaffected by this process and will appear in the product.

Nickel hydrogenation catalysts used in the process must be reduced prior to use. To accomplish this, the catalyst is heated to 700-750° F in a hydrogen stream. The heater shown on the flow sheet is for this purpose and may be either a gas or oil fired unit.

Operating Conditions: Desulfurization of the charge benzene is preferably carried out at 200° F and approximately 550 psig, whereas the main hydrogenation step is conducted at 550° F and 500 psig. Space velocities of 1 to 3 cubic feet per hour per cubic foot are employed in the fixed bed hydrogenator. The product cyclohexane is condensed and collected at 100° F.

Yields: Cyclohexane yield is essentially stoichiometric, based on benzene charged to the system.

Licensor: Krell and Associates, Inc.



Dehydrogenation— HOUDRY PROCESS CORPORATION

Application: An adiabatic fixed bed catalytic process for dehydrogenation of light hydrocarbons. Process may be operated to produce both mono- and di-olefins.

Charge: Three to five carbon paraffins, mono-olefins and mixtures thereof comprise the feed stock.

Products: Propylene from Propane; C_4 mono-olefins from normal and iso-butane; Butadiene from n-butane, n-butene or mixtures thereof; C_5 mono-olefins from normal and iso-pentane; and Isoprene from iso-pentane, iso-pentene or mixtures thereof.

Description: In a typical operation, the feed is preheated to reaction temperature prior to contact with catalyst in the fixed-bed reactors. Hot effluent from the reactors is cooled in a quench tower by direct contact with circulating oil, then passes to compression, cooling and a conventional absorption and stabilization system. The stabilized product stream is then delivered to an appropriate extraction system for recovery of the high purity product. Mono-olefins, when not removed as product, are returned with the paraffin recycle stream to the charge accumulator.

Power operated valves are controlled by a special cycle timer which programs the reaction, purging and regeneration sequences of the reactor system. Hydrocarbons are purged from the on-stream reactor prior to regeneration and combustion gases are purged after regeneration.

Catalyst: The catalyst employed is in the form of cylindrical pellets consisting of active alumina impregnated with chromic-oxide. Catalyst is regenerated in the reactors by burning off the coke deposit with preheated air. Inert granular material of high heat capacity may be mixed with the active catalyst in predetermined amounts to obtain the desired heat capacity of the catalyst bed. A catalyst life of over 18 months has been obtained.

Operating Conditions: In this cyclic process the operating conditions are chosen to be essentially adiabatic in nature, with the heat required for reaction during the on-stream period virtually the same as that supplied by combustion of coke deposit during catalyst regeneration. The major process conditions normally will be within the following ranges:

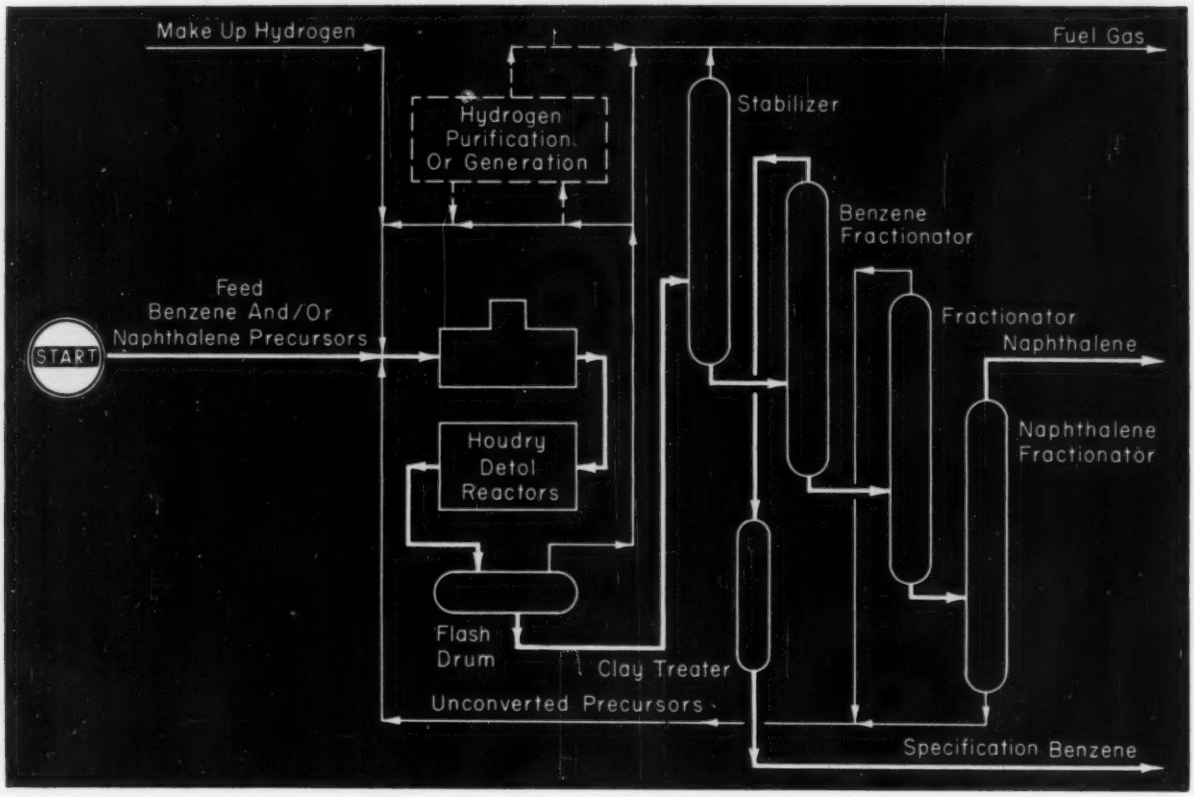
Temperature	—1000°-1200° F.
Pressure	—5″ Hg absolute or higher
Space Rate	—1 to 3 Vol. of Charge/Vol. of Catalyst/Hour
On-stream Period	—5-15 minutes

Yields: Typical ultimate yields of isoprene and butadiene from a mixed isopentane and normal butane feed stream are shown in the table below.

Component, Percent by Weight	FEED			Reactor Products Total	NET PRODUCTS (Percent of Fresh Feed)			
	Fresh	Recycle	Total		Fuel Gas	Butadiene Product	Piperylene Product	Isoprene Product
Dry Gas	....	....	....	6.1	30.5	...	..	..
Isobutane	1.0	3.9	3.3	3.1	...	...	..	..
Isobutylene	....	7.1	5.7	5.8	0.5	...	..	..
n-Butylenes	....	25.7	20.6	20.8	0.5	0.5	..	..
n-Butane	81.5	46.6	53.5	37.3	0.5	...	..	..
Butadiene	....	0.4	0.3	9.8	...	47.5	..	..
Isopentane	16.5	12.2	13.1	9.8	...	...	..	..
Isopentenes	....	3.5	2.8	2.9	...	...	0.4	0.1
Isoprene	....	0.1	0.1	2.0	...	...	..	9.5
n-Pentane	1.0	0.1	0.3	0.1	...	...	..	..
n-Pentenes	....	0.4	0.3	0.3	...	...	..	..
Piperylene	....	....	....	0.3	...	...	1.5	..
C_6+, Coke, C & H_2 to CO, CO_2 & H_2O	....	....	....	1.7	...	...	..	..
Total	100.0	100.0	100.0	100.0	32.0	48.0	1.9	9.6

Commercial Installations: Eleven units are in operation or under construction with a total nominal design capacity in excess of 392,000 annual short tons in terms of butadiene.

Reference: PETROLEUM REFINER, Dec. '54 p. 173; *Chemical Engineering Progress,* May '61 p. 35.



Detol — HOUDRY PROCESS CORPORATION

Application: The production of ultra high purity benzene and naphthalene respectively from alkyl benzenes and alkyl naphthalenes by a fixed bed catalytic process.

Charge: Alkyl benzene, alkyl naphthalene and other benzene or naphthalene precursors or mixtures thereof may comprise the feedstock.

Products: Benzene produced meets acid wash and corrosion tests and has a freeze point of 5.4° C or higher. Naphthalene produced has a melting point higher than 79.6° C.

Description: Process equipment required is simple, easy to operate and control. A composite flow scheme is depicted by the above schematic flow diagram; however, the distillation equipment is dependent upon the composition of the charge and therefore, may vary. In a typical operation the feedstock at elevated pressure together with unconverted precursors, hydrogen make-up and recycle hydrogen passes through a heat exchanger train and a fired furnace for heating to the required reaction temperature. The hot feed then passes through reactors containing catalyst, wherein the precursors are dealkylated or dehydrogenated, depending upon the precursors under consideration. Materials not producing aromatics are converted to light hydrocarbons.

The reaction proceeds at high conversion rates and at very high selectivities. Reactor effluent is cooled and passed to a flash drum. Liquid from the flash drum is transferred to a stabilizer for the removal of dissolved hydrocarbons boiling below benzene. Product(s) of desired purity are fractionated from the stabilizer bottoms, the unconverted charge being recycled back through the reactors. When producing high purity benzene, clay treating is recommended.

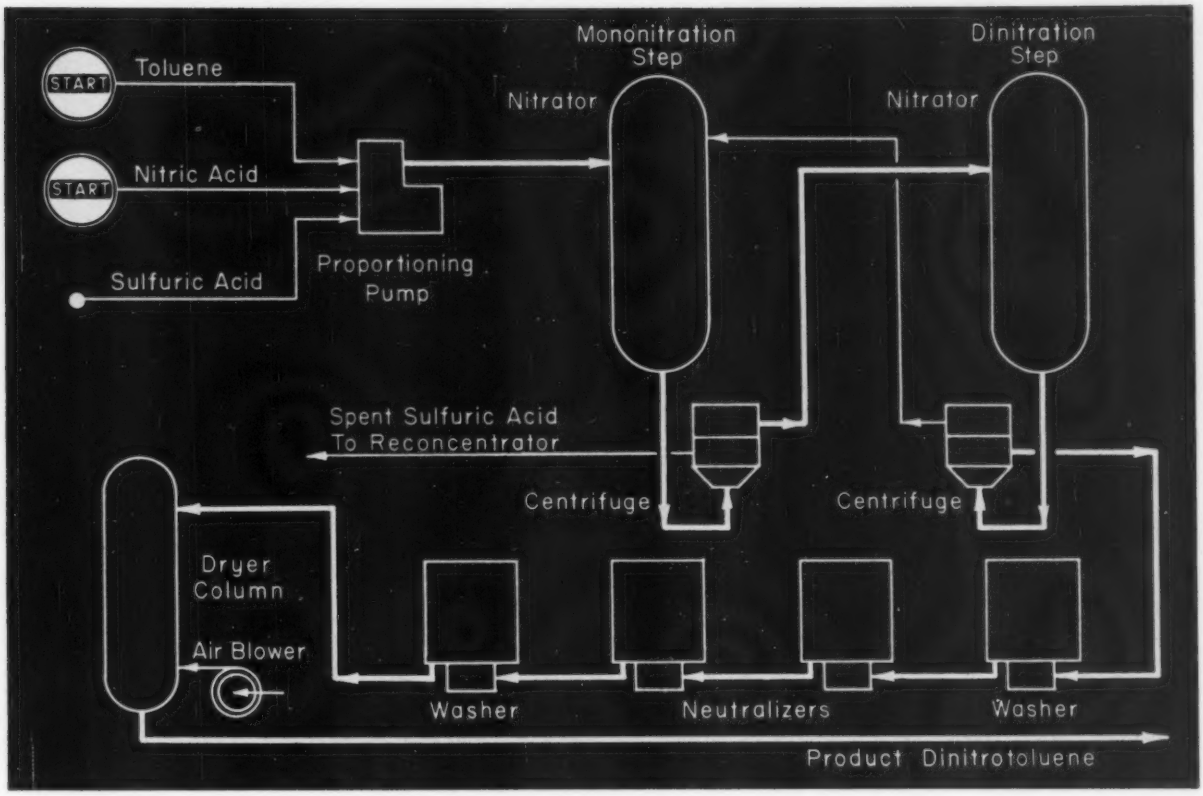
Hydrogen-rich vapors are withdrawn from the flash drum and recycled to the reactors. Depending upon the quantity and purity of available feed hydrogen, it may be desirable to include a hydrogen concentration step to maintain the desired hydrogen concentration in the system. Sufficient hydrogen may be produced, if desired, by reforming some of the light hydrocarbons in the effluent gas to make the operation completely independent of external sources of hydrogen.

Catalyst: The catalyst in the form of cylindrical pellets is rugged and poison resistant. Occasonial regeneration is easily accomplished in situ by burning off the coke with preheated inert gas containing controlled quantities of air.

Operating Conditions: Temperature 1000-1200° F. Pressure 500-1200 psig.

Yields: Selectivity for conversion of alkyl benzenes and alkyl naphthalenes to benzene and naphthalene, respectively, is 97-98 mole percent. Additional naphthalene, as well as benzene, is produced when the feed also contains cyclic compounds such as decalin, tetralin and indane.

Reference: PETROLEUM REFINER, June 1961 p. 228.



Dinitrotoluene (Meissner Process) — GIRDLER CORPORATION

Application: A process for the manufacture of dinitrotoluene (DNT).

Charge: Nitration Grade Toluene, 95 to 98 percent nitric acid and 90 to 96 percent sulfuric acid.

Product: High purity dinitrotoluene.

Description: The nitration of toluene to DNT is carried out continuously in a two step operation. The reactants are careful metered in a proportioning pump which feed toluene, nitric acid and sulfuric acids in the correct ratios to the nitrators. The nitration temperature of each reactor is controlled so that the desired isomer ratio of product DNT is held constant.

Spent acid of 70 to 75 percent H_2SO_4 is a by-product which may be reconcentrated and reused. The spent acid from each stage of nitration is separated from the nitrated toluene in specially designed centrifuges. The more concentrated spent acid from the dinitration stage is returned to the mononitration step.

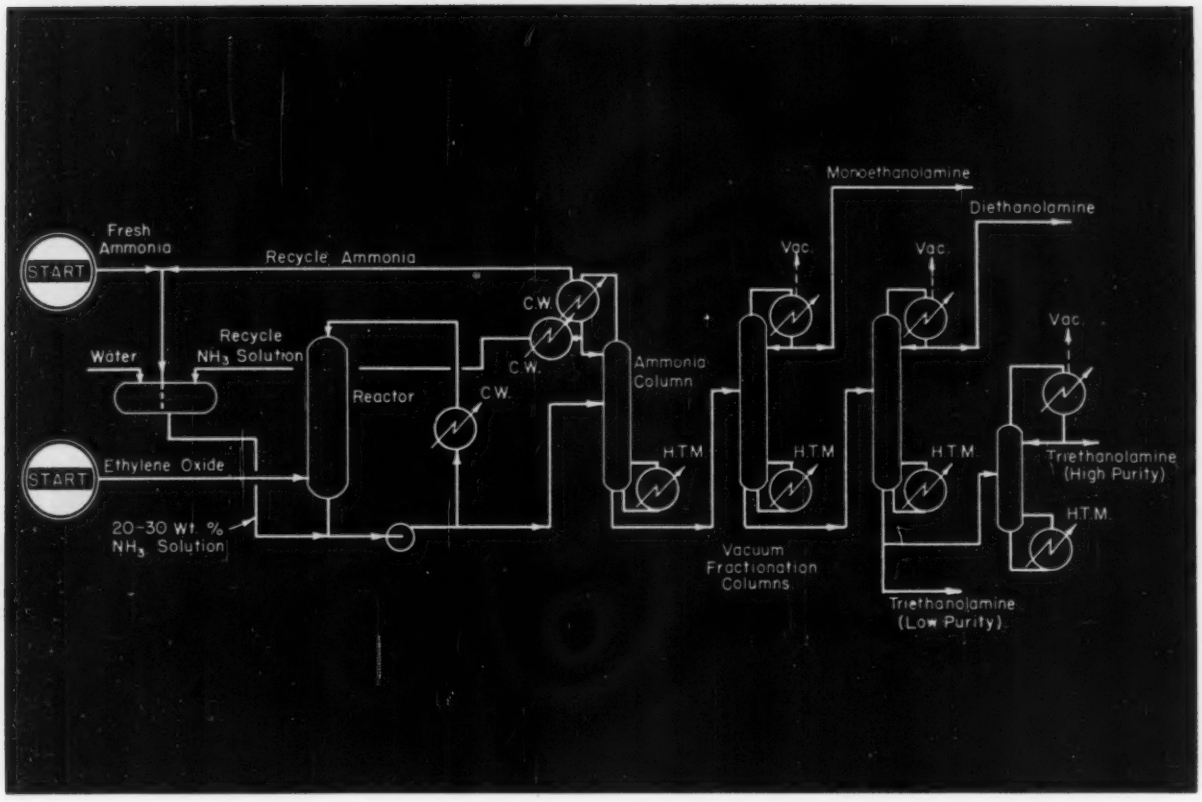
The DNT from the nitration step is thoroughly washed, neutralized and rinsed in washer-separator apparatus employing the parallel and countercurrent principle so as to use the least amount of water and to minimize the loss of DNT. The wash water and weak soda ash solution are added to the washers by rotameters.

The DNT from the washers is fed to a steam heated drying column where the moisture can be reduced to less than 0.25 percent.

The Meissner nitrators provide excellent internal mixing and large cooling surfaces for the volume of liquid handled. Thus instantaneous and large temperature rises from the reaction of the raw materials are prevented. The composition of the reaction mixture is always constant and it is possible to adjust the necessary conditions of the nitration to secure an optimum. Conditions are chosen and readily maintained to prevent side reactions almost completely.

Commercial Installations: Several DNT plants utilizing the Meissner process are in operation, one is in the U.S.A. Many other Meissner nitration plants, similar in design to DNT plants, are in operation throughout Europe.

References: *Industrial and Engineering Chemistry*, Vol. 46, pp 718-724, April '54.



Ethanolamines

Application: A process for the manufacture of ethanolamines.

Charge: Ethylene Oxide, 99.5 percent purity; anhydrous ammonia.

Products: Monoethanolamine $NH_2C_2H_4OH$, 99 wt % purity; Diethanolamine $NH(C_2H_4OH)_2$, 98 wt % purity; Triethanolamine $N(C_2H_2OH)_3$, 98 wt % purities.

Description: Monoethanolamine (MEA), diethanolamine (DEA), and triethanolamine (TEA) are produced commercially by reacting ethylene oxide and ammonia. Through control of reaction conditions the distribution of the amines in the product may be varied in accordance with market requirements. Since 1956 DEA has been in greatest demand; but in 1953 MEA was the leader and in 1951 more TEA was produced than DEA and MEA combined. Thus, commercial plants for the production of ethanolamines must be somewhat flexible to accommodate market variations.

Liquid ethylene oxide is charged separately to the reactor, where it is contacted by a 20-30 wt % aqueous ammonia solution in the presence of an excess of recycled reaction product. The reactions are quite rapid and exothermic, and reactor design is predicated on efficient means for heat removal and temperature control. Designs in practice include both the tower type (with reaction mixture recirculating through heat exchangers) and the cooled "pipe line" type. The reactor contents are maintained at 85-100° F. Sufficient pressure must be maintained to ensure a liquid phase, and for designs with high circulation can be as low as 10-20 psig.

Since ethylene oxide reacts faster than MEA and DEA than with ammonia, careful control of the ethylene oxide: ammonia ratio is exercised. The effect of reactant ratio is shown in the following tabulation:

Weight Ratios of Ethanolamines in Reactor Product

	Moles ethylene oxide/mole ammonia		
	0.1	0.5	1.0
MEA	75-61	25-31	12-15
DEA	21-27	38-52	23-26
TEA	4-12	37	65-59

In practice, the ratio will range from 0.1 to 2.0 moles ethylene oxide per mole of cantained ammonia, with usual operations employing ratios of 0.3-0.6. Conversion of ethylene oxide is essentially complete, with yields of the desired amines on the order of 95%. Some heavy ends are formed, these being principally higher ethylene oxide ethers of TEA.

The net reaction product is withdrawn from the reactor and fed to a stripping system wherein ammonia and water are removed at about 50 psig, and water at atmospheric pressure. These products are returned to the ammonia solution tank where they are blended with fresh ammonia. When operations are such that high yields of TEA are produced, the bottoms from this column may be marketed directly as lower purity (83 wt %) triethanolamine. Otherwise, the bottoms stream is fed to the vacuum distillation columns for further separation.

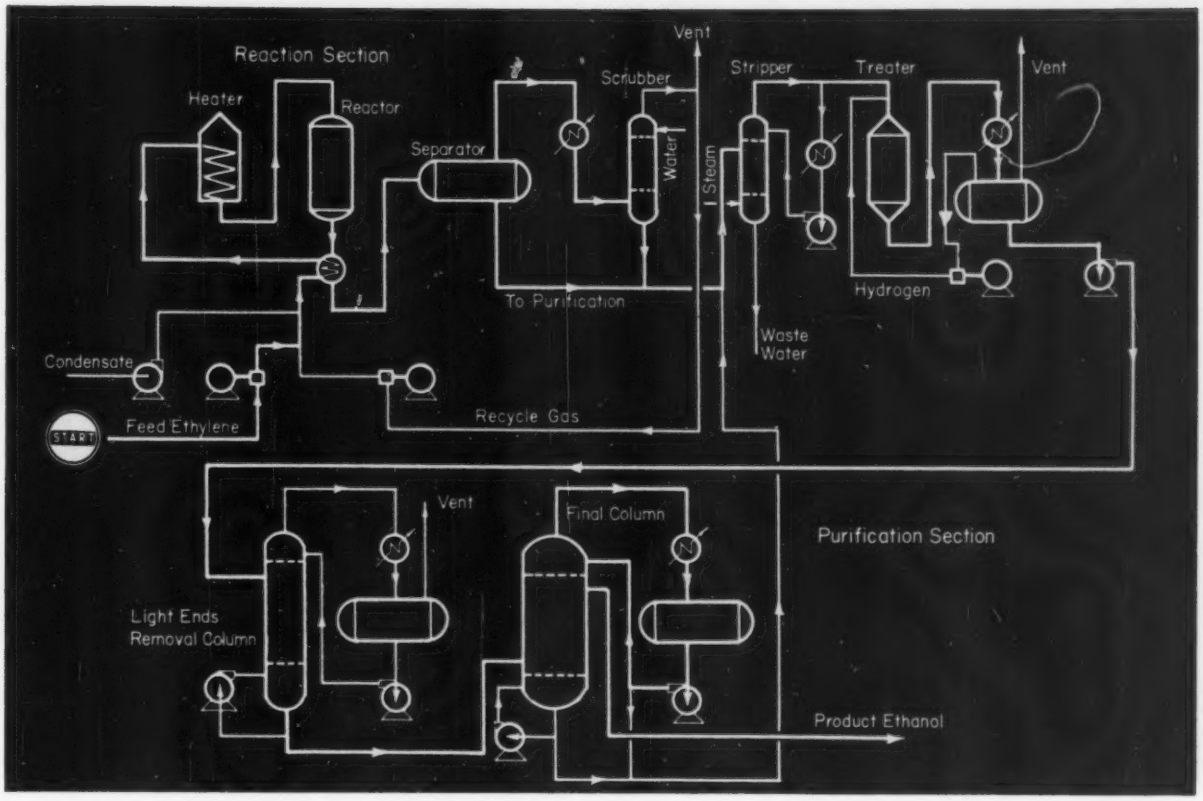
The vacuum columns are designed for a high degree of flexibility in operation. They are of stainless steel construction, contain 20-30 trays, operate at less than 10 mm Hg., and are reboiled by Dowtherm or equivalent heat transfer medium. The overheads from the first two columns are 99% MEA and 98% DEA products. The bottoms from the second column may be sold as lower-purity commercial TEA, but in general are fed to a final vacuum column to improve color and increase purity to 98 wt.%.

The ethanolamines are stored conventionally, and shipped from the plant in steel drums and tank cars.

Operating Conditions: Reaction conditions vary with the distribution of three amines desired; a discussion of this point is included in the above text.

Yields: Over-all process yields of the three amines are on the order of 95 percent, based on both ethylene oxide and ammonia.

Commercial Installations: This process or a variation is used by Union Carbide Chemicals Corp., So. Charleston, W. Va., and Seadrift, Texas; Dow Chemical Co., Sarnia, Ont. and Freeport, Tex.; Jefferson Chemical Co., Port Neches, Tex.; Allied Chemical Corp., Orange, Tex.; and Olin-Mathieson Chemical Corp., Brandenburg, Ky.



Ethanol— SHELL DEVELOPMENT COMPANY

Application: A process for the manufacture of ethanol.

Charge: Ethylene gas (97 percent purity) and water vapor.

Products: Ethanol 95 volume percent purity.

Description: The reaction section shown is only one of several parallel units making up the plant. The feed ethylene is compressed to approximately 1,000 psi in the feed compressor. This stream is combined with the recycle stream from the recycle gas compressor and joined by a controlled stream of water in the ratio of 0.6 moles of water per mole of ethylene. This stream is pre-heated by exchange with the reactor product and totally vaporized in a gas fired furnace and heated to a final temperature of 570° F before going into the top of the reactor.

The feed passes downward through the catalyst bed (phosphoric acid supported on diatomaceous earth) and a fraction of the ethylene and water is converted to ethyl alcohol on each pass through the reactor. Since the reaction is exothermic, products leave the reactor at slightly higher than the feed temperature.

The reactor product is exchanged with feed, neutralized with caustic soda and separated into liquid and vapor in a high pressure separator. The liquid product goes to the purification section. The vapor is cooled in the recycle gas cooler and scrubbed to remove ethanol. This ethanol-water mixture is sent to the purification section and the gas from the scrubber is recycled. Some of the recycle gas is vented to the ethylene plant to limit concentration of ethane and methane in the reactor feed.

The crude product from the several parallel reactor streams is combined and separated in a low pressure separator. This crude stream is steam stripped, the bottoms going to waste, and the overhead going to the treater. In the treater, the crude stream is combined with a recycle hydrogen stream and, over a nickel catalyst, the trace amounts of aldehydes are converted to the corresponding alcohols.

In the final purification section the light-ends column removes light byproducts, principally diethyl ether, and the final column purifies the ethanol.

Reactions: In the Shell hydration process, ethylene and water combine chemically by the reaction:

$$C_2H_4 + H_2O \xrightarrow{H_3PO_4} C_2H_5OH + 19{,}000 \text{ BTU/LB. Mole}$$

The primary side reaction forms diethyl ether by dehydration of ethanol:

$$2\,C_2H_5OH \xrightarrow{\text{Catalyst}} (C_2H_5)_2O + H_2O$$

Acetylene, present as an impurity in the feed ethylene, forms acetaldehyde:

$$C_2H_2 + H_2O \xrightarrow{\text{Catalyst}} CH_3CHO$$

In addition, a small amount of ethylene polymerizes to form less than one percent of a wide range of olefinic polymers.

The hydrogenation reaction converts the aldehydes to alcohols over a nickel catalyst. In this way acetaldehyde is converted to ethyl alcohol:

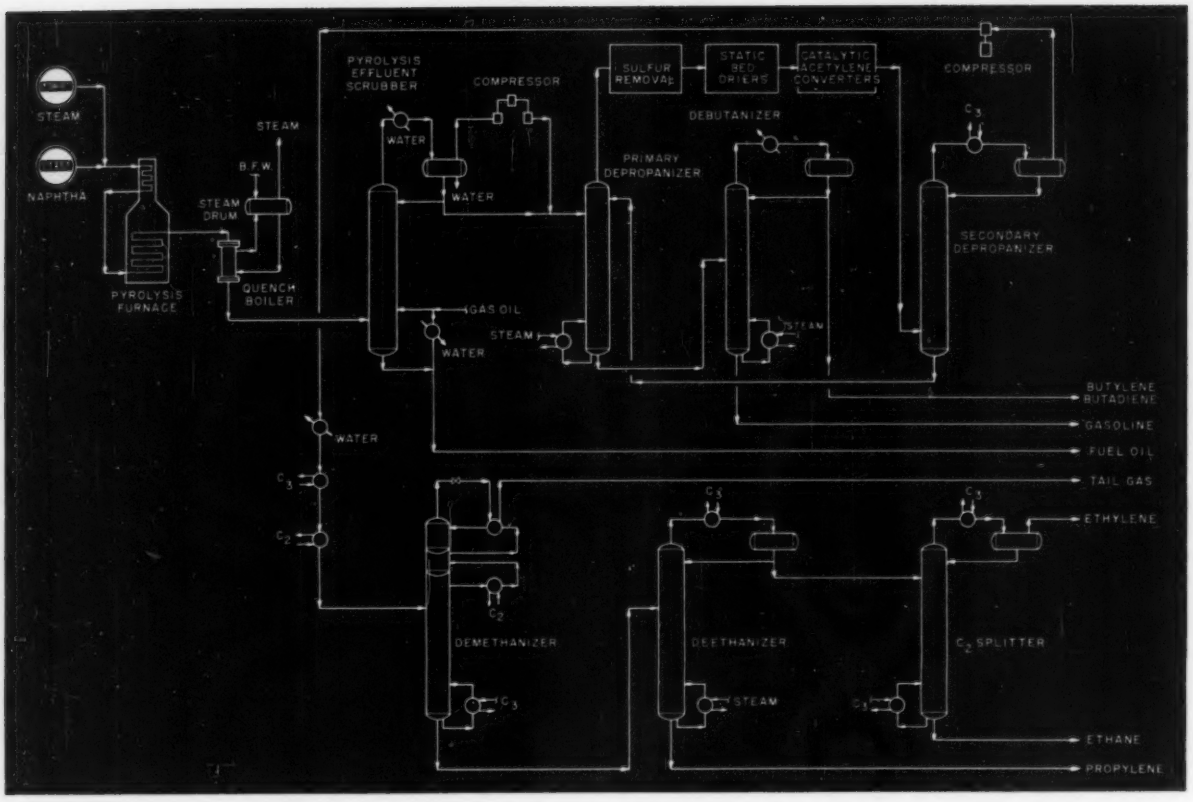
Operating Conditions: The conditions for the ethylene hydration reaction are as follows:

Reaction temperature	570° F.
Reaction Pressure	1000 psig
Reactor feed ethylene concentration, water free basis	85 percent
Ethylene make-up concentration	97 percent
Water-to-ethylene mole ratio in feed	0.6
Space Velocity, VSVM	30
Ethylene conversion per pass	4.2 percent
Water conversion	7.0 percent

Yields: Over-all process yield, ethylene to alcohol, is 97 percent or better.

Commercial Installations: This process or a variation is used by Shell Chemical Co., Houston; British Petroleum Chemicals, Ltd., Grangemouth, Scotland; Erdol Chemie G.m.b.H., Dormagen, W. Germany.

Reference: *Chemical Engineering Progress,* Oct. '54.



Ethylene— THE M. W. KELLOGG COMPANY

Application: A process for the production of ethylene by the steam pyrolysis of petroleum feeds.

Charge: Refinery gas, ethane, propane, butane, pentane, natural gasoline, light and heavy naphthas, gas oil and heavier fractions.

Products: Ethylene in purities up to 99.9 mole percent also valuable olefinic and aromatic products in addition to a tail gas consisting of hydrogen and methane.

Description: The flow diagram illustrates a typical low temperature fractionation unit for producing ethylene from a naphtha charge stock. Naphtha and steam pass through the high temperature coils in the pyrolysis furnace, where cracking takes place.

The cracked products are partially cooled in steam generating facilities before final cooling in a scrubber column from which a fuel oil fraction is withdrawn.

The overhead, consisting of gasoline and lighter components, is compressed and charged to a split depropanizer system from which propane and lighter components are separated from butane and heavier. Sulfur removal, drying and acetylene conversion also take place in the split depropanizing step.

The depropanized bottoms flow to a debutanizer from which C_4s are withdrawn as an overhead product and gasoline as a bottoms product.

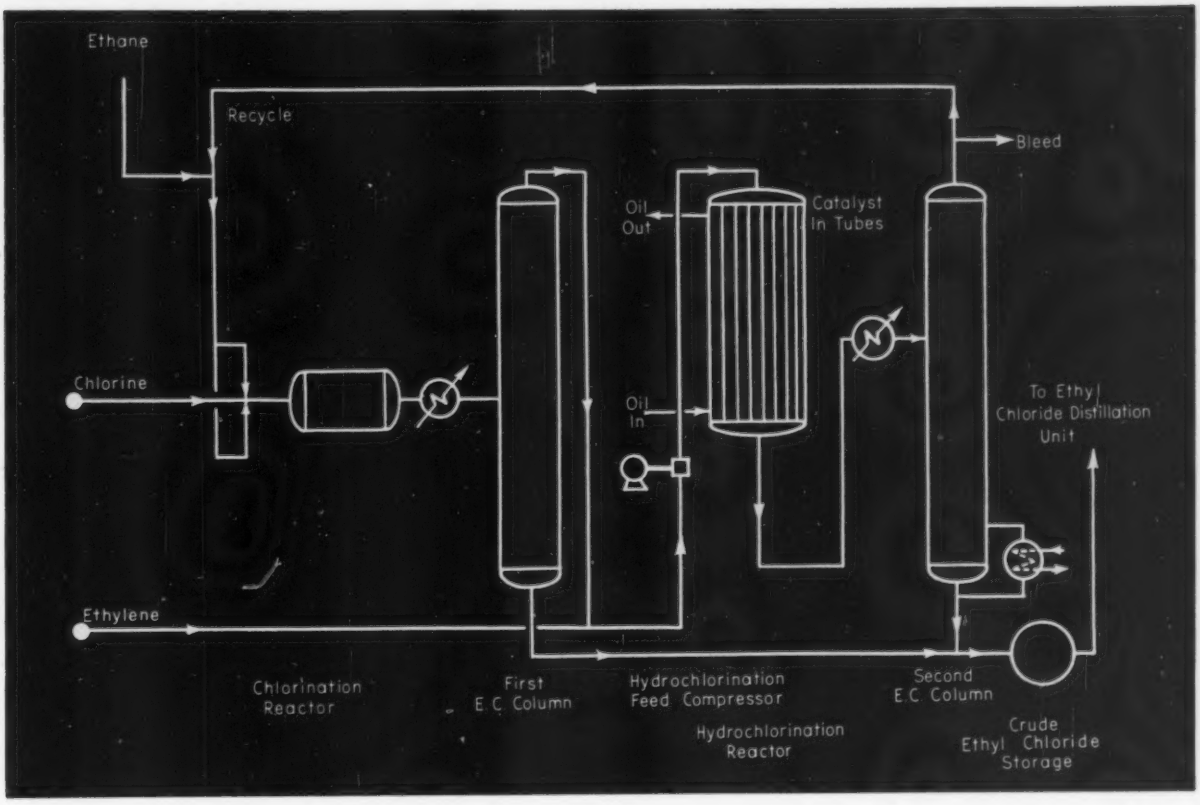
Depropanizer overhead is compressed and sent to the demethanizer where methane and hydrogen are removed as an overhead product by low temperature fractionation. The demethanizer bottoms flow to the de-ethanizer from which the C_2s are separated from the bottoms C_3 product.

The C_2 stream is separated by low temperature fractionation into an ethylene product stream and an ethane product stream which could also be vaporized and cracked to yield additional ethylene.

Refrigeration is supplied by an external propylene-ethylene cascade system and also by gas expansion.

Yields: Ethylene yields of 25 weight percent may be produced in the naphtha pyrolysis furnace effluent. The ethane produced from this pyrolysis could also be cracked to yield approximately 4 additional weight percent ethylene. The C_3 product fraction consists of 90 to 95 percent propylene thereby eliminating the need for propane-propylene splitting. The C_4 fraction is over 95 percent unsaturated and contains a high percentage of butadiene. A high octane gasoline product is also produced in this process.

Commercial Installations: Fifteen plants have been designed and built or are being built to yield a total production of approximately 5 million pounds per day of ethylene.



Ethyl Chloride— SHELL DEVELOPMENT COMPANY

Application: A combination of substitutive chlorination of ethane and hydrochlorination of ethylene for the manufacture of ethyl chloride.

Charge: Ethane, chlorine and ethylene.

Products: Ethyl chloride.

Description: Chlorine, ethane, and a recycle gas stream which may contain ethylene are fed to the chlorination reactor. The combined ethane and recycle are pre-heated. The chlorine enters as a vapor. The reaction is exothermic and is carried out adiabatically. The reactor exit stream is cooled and sent to the first ethyl chloride column where the inerts, unreacted ethane, hydrogen chloride and some of the ethyl chloride are taken overhead. The remainder of the ethyl chloride and other chlorinated by-products leave as bottom product and are sent to crude ethyl chloride storage.

The overhead stream from this first column plus fresh ethylene is compressed, preheated and fed to the hydrochlorination reactor, where 50-80 percent of the ethylene and the hydrogen chloride combine. In this reaction, temperature is a more important variable than it is in chlorination, and the reaction is carried out isothermally, heat being removed by circulating oil.

The hydrochlorinator exit stream is cooled and fed to the second ethyl chloride column where crude ethyl chloride is taken out as bottoms and sent to crude ethyl chloride storage. The overhead consisting of ethane, inerts, unreacted ethylene and hydrogen chloride is recycled to the chlorinator. It is necessary to vent a portion of this stream to prevent buildup of inerts. The crude ethyl chloride is fed to the ethyl chloride distillation unit, where it is purified in a straight-forward manner by passing first through a heavy-ends column and then through a light-ends column.

In the chlorination reaction, the chlorine disappears completely. Some of the ethylene reacts, but some ethylene is formed by ethyl chloride cracking. Moles of HCl formed exceed slightly the moles of chlorine fed.

In the hydrochlorination reaction the addition of fresh ethylene to the gas stream from the first ethyl chloride column is automatically controlled so that the ethylene-to-hydrogen chloride feed ratio is 1:1. This ratio is not critical, but 1:1 appears to be optimum. Since one mole of ethylene reacts with one mole of hydrogen chloride, the ethylene-hydrogen chloride ratios in the reactor exit, recycle, and vent gas streams are also 1:1.

Reactions: The ethane chlorination reaction in this process is carried out in the presence of ethylene at or above 750° F. It produces ethyl chloride and hydrogen chloride:

$$Cl_2 + C_2H_6 \rightarrow C_2H_5Cl + HCl$$

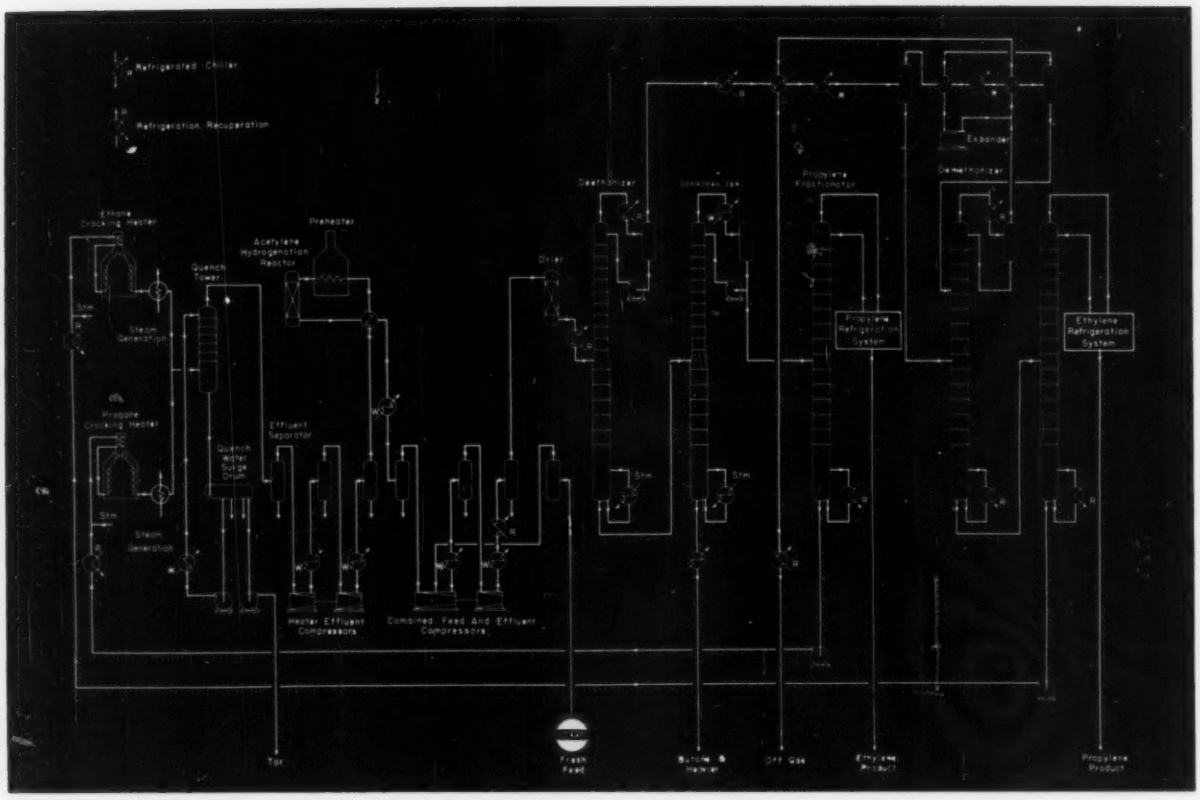
The hydrogen chloride produced in the chlorination reaction is used in the ethylene hydrochlorination reaction which is carried out in the vapor phase at elevated pressure in a reactor packed with catalyst:

$$HCl + C_2H_4 \rightarrow C_2H_5Cl$$

Yields: 90 percent over-all yield, ethane plus ethylene to ethyl chloride, and 95 percent chlorine to ethyl chloride.

Commercial Installation: Associated Ethyl Co., Ltd., Ellesmere Port, Cheshire, England.

Reference: *Industrial and Engineering Chemistry,* Vol. 47,No.5,May'55. U.S. Patent No. 2,807,656 (Sept. 24, 1957).



Ethylene and Propylene— THE LUMMUS COMPANY

Application: A process for the production, recovery and purification of ethylene and propylene.

Charge Stock: Refinery gases, ethane or propane.

Products: Ethylene and/or propylene at the desired purity up to 99.9-mole percent.

Description: The flow diagram illustrates a plant to produce ethylene and propylene from ethane and propane, and to recover these olefins.

Ethane and propane entering as fresh feed plus unconverted ethane and propane are recovered to provide the feed to the cracking heaters.

Separate furnaces are used for cracking ethane and propane in order that each be cracked at the optimum conditions for maximum yield and on-stream time. The effluents from the furnaces pass through transfer line exchangers and are combined and further cooled in water scrubbing tower before introduction to the compression system. Polymer and aromatic distillate are collected in the quench water surge drum and decanted there.

When the ethylene must be acetylene-free, the acetylene is selectively hydrogenated by passing the cracking heater effluent over a catalyst, generally after the second compression stage.

The combined heater effluent and fresh feed is compressed to approximately 500 psig, chilled, and dried over soild desiccants such as activated alumina or bauxite. The dryers consist of multiple desiccant chambers which are regenerated on a predetermined cycle.

The dried feed gas is further chilled and introduced into the deethanizer operating at 450 psig. Hydrogen, methane, ethane and ethylene are taken overhead and proplene, propane, and C_4 and heavier bottoms are charged to the depropanizer. The deethanizer overhead is then chilled by exchange and ethylene refrigeration to —130° F. The remaining vapor is further chilled to about —195° F. The condensed liquids are charged to the demethanizer. The residual vapor is expanded in a centrifugal expander to the fuel gas system pressure. The low temperature produced in the expander is used to produce the final cooling of the feed gas to —195° F.

The demethanizer overhead goes to fuel and the bottoms (recovered ethane and ethylene), is charged to the ethylene fractionator operating at about 60 psig. The ethylene fractionator is integrated with the ethylene refrigeration system for reflux and reboil heat. The ethylene product is taken overhead and the ethane bottoms are recycled to the ethane heater.

The depropanizer takes propylene-propane overhead and C_4 and heavier as bottoms. The propylene-propane is charged to the propylene fractionator operating at about 20 psig. Propylene products is taken overhead and propane bottoms are recycled to the cracking heater or withdrawn as LPG.

Refrigeration for the unit is supplied by centrifugal compressors operating in a cascade system.

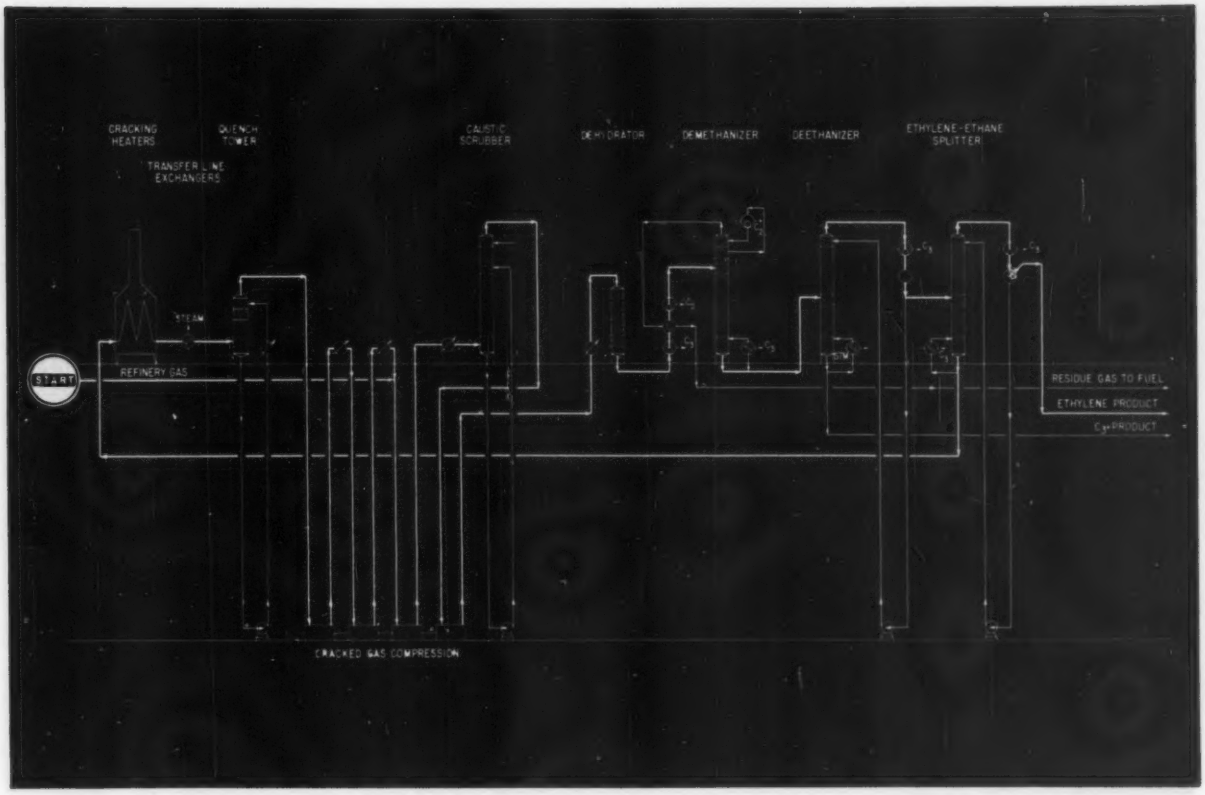
Yield: One million SCF of refinery feed gas gives yields as follows:

Refinery Gas	Volume Percent	Product Pounds
Hydrogen plus inert	7.4	———
Methane	28.5	———
Ethylene	9.9	32,200
Ethane	33.9	———
Propylene	3.3	7,800
Propane	13.4	———
C_4 and heavier	3.6	8,900
Fuel Gas	———	855,000 SCF

A modification of the fractionation system shown above permits the manufacture of ethylene and propylene from naphtha charge stocks. Ethylene of purities to 99.9+ volume percent may be produced with this system.

Commercial Installations: The Lummus Company has designed and constructed 24 units producing ethylene and/or propylene from various feed stocks.

Reference: PETROLEUM REFINER, Vol. 33, No. 7, July 1954, p 135.



Ethylene — STONE & WEBSTER ENGINEERING CORPORATION

Application: A process for the production of ethylene and propylene from various distillate or light hydrocarbon feed stocks.

Charge: Designs are available for charging hydrocarbon feed stocks ranging from ethane to gas oil, including refinery gas.

Products: The primary products are high purity ethylene and propylene. Principal byproducts are residue gas, substantially hydrogen and methane, and a C_4's plus stream from which may be recovered butylenes and butadiene, and B-T-X aromatics.

Description: The flowsheet shows the processing scheme employed with refinery gas feed. The feed gas is combined with the gas from the cracking furnaces, compressed to about 500 psig and thoroughly dried. An aromatic rich condensate is separated in the compression system and combined with the depropanizer bottoms. The dried mixture of feed gas and cracked gas is cooled and demethanized at 475 psig utilizing ethylene refrigerant at −150° F. Hydrogen and methane are taken overhead. The bottoms, essentially free of methane, pass to a deethanizer where ethylene and ethane are taken overhead. Propylene and heavier are discharged as a bottoms stream which is sent to a depropanizer (not shown). The ethylene is separated in an ethylene-ethane splitter, operating at 225 psig.

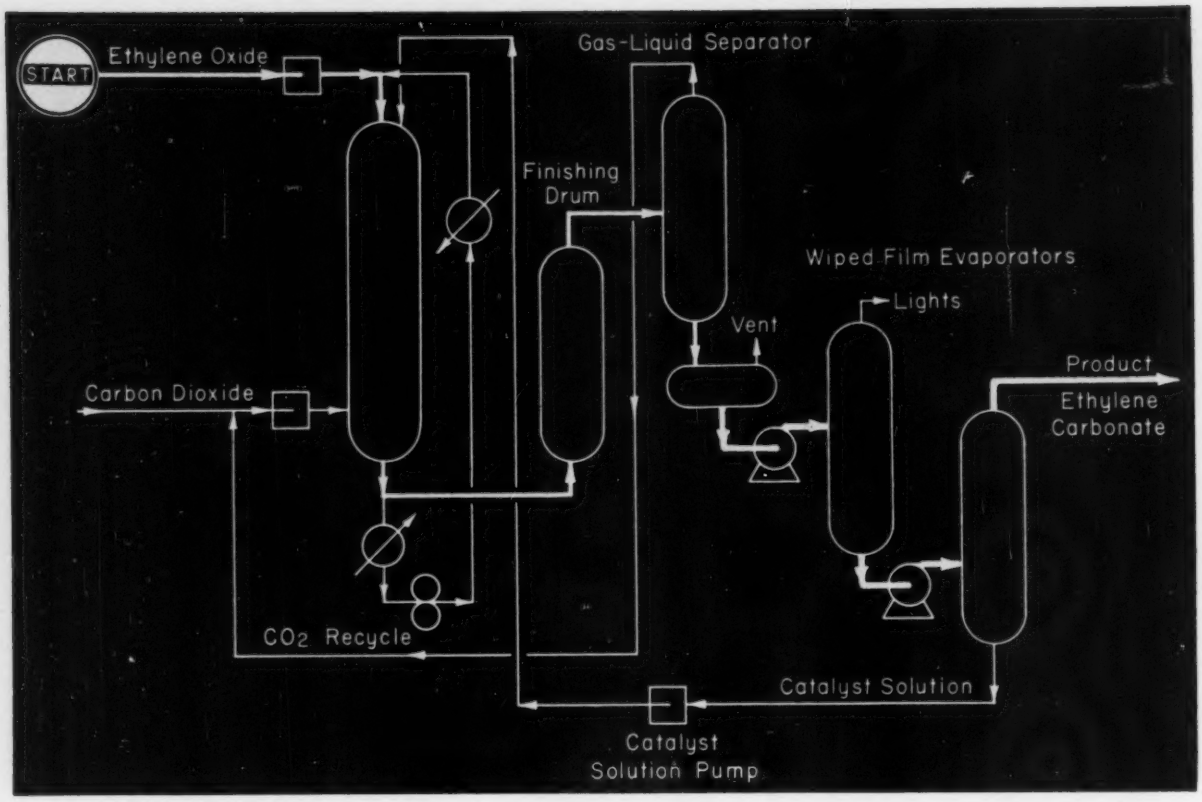
For polyethylene grade ethylene it is necessary to provide additional rectifying trays in the splitter, and to include acetylene removal facilities. This is accomplished by catalytic hydrogenation over highly selective catalysts, located either in the cracked gas compression system or in the deethanizer overhead.

Ethane separated in the fractionation section, and C_3's if not desired as a product, are recycled to tubular cracking furnaces where they are cracked in mixture with dilution steam. If the feed stock is ethane, propane or butane, the vaporized feed is charged directly to the cracking furnace. Naphtha and other distillate feed stocks are processed in similar fashion, but the substantial amount of aromatic distillate and fuel oil in the coil effluent requires additional facilities for separating and stabilizing these streams. Refrigeration is by an ethylene-propane cascade system. Ethylene losses in the residue gas are kept to a low value by supplemental cooling with an expansion system.

Yields: Yields of ethylene from cracking ethane and propane are approximately 80 and 48 weight percent respectively. Ethylene yields from naphtha range from 20 to 28 weight percent depending on the feed stock characteristics.

Commercial Installations: Thirty-seven plants with a combined production of 10 million pounds per day.

Reference: PETROLEUM REFINER, July '54, p 135.



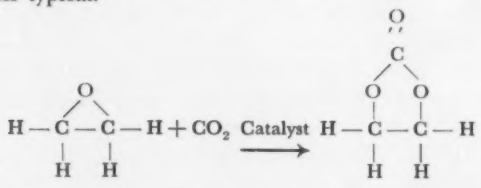
Ethylene Carbonate— JEFFERSON CHEMICAL COMPANY, INC.

Application: A process for the manufacture of alkylene carbonates.

Charge: Ethylene oxide or propylene oxide and carbon dioxide.

Products: Ethylene carbonate from ethylene oxide and propylene carbonate from propylene oxide.

Description: The alkylene carbonates can be prepared readily from the corresponding 1, 2-epoxides and carbon dioxide. The preparation of ethylene carbonate is more or less typical.



Ethylene Oxide Carbon Dioxide Ethylene Carbonate

The reaction of ethylene oxide with carbon dioxide is initiated by a quaternary ammonium halide catalyst at about 300° to 350° F. A large excess of carbon dioxide is maintained to insure substantially complete conversion of the ethylene oxide. This requires a reaction working pressure of 1,000 to 1,500 psig. The reaction is extremely exothermic and heat transfer is an important consideration in reactor design.

A considerable number of quaternary ammonium halides can serve as catalysts, solubility in the reaction mixture being an important requirement. Tetraethylammonium bromide is particularly easy to prepare. If desired, this catalyst can be prepared directly in the ethylene carbonate as a solvent.

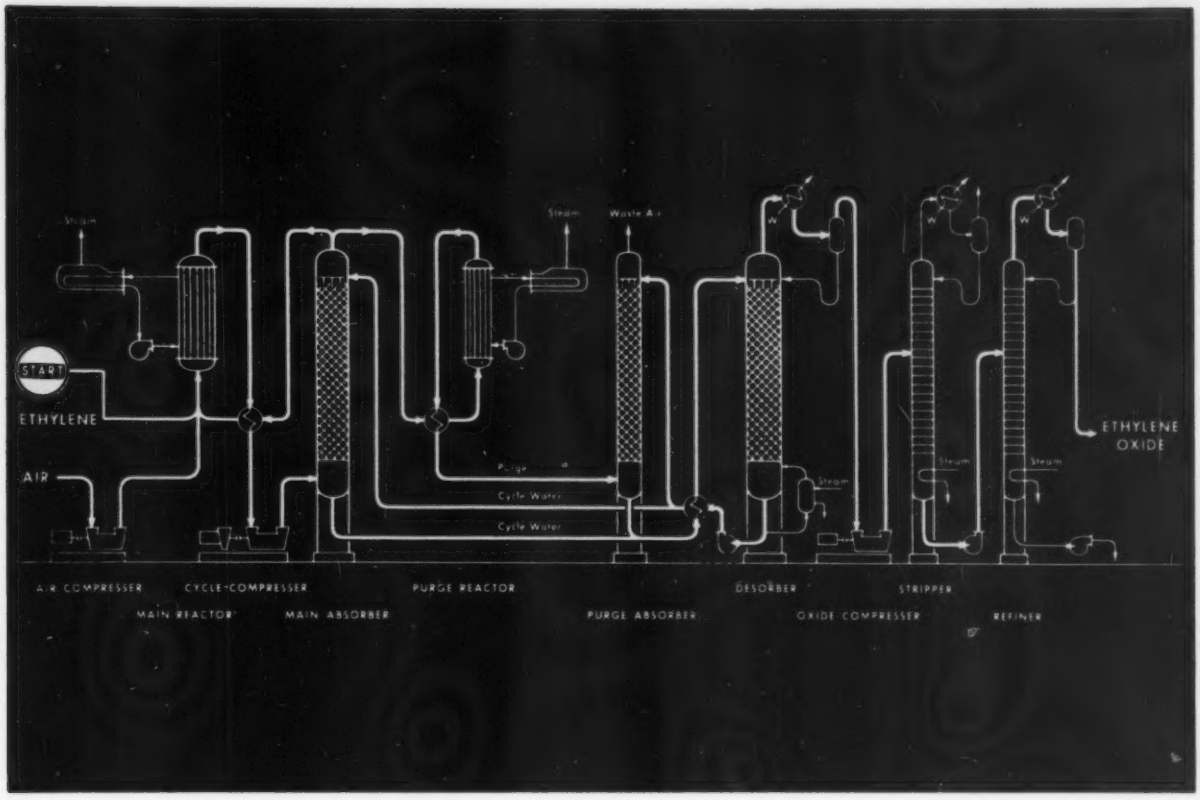
A continuous system for the preparation of ethylene carbonate is illustrated above. Ethylene oxide and the catalyst solution are introduced from storage by means of high pressure pumps. Carbon dioxide is delivered to the reactor by a compressor set at 1500 psig. Mixing is obtained by a recycle pump that circulates the reaction mixture through two heat exchangers. Reactor holding time averages 30 to 60 minutes.

A small finishing drum is used to ensure completeness of the reaction.

The product is let down to 5 psig in a gas-liquid separator where the bulk of the excess carbon dioxide is released and recycled to the carbon dioxide compressor.

Traces of carbon dioxide and unreacted ethylene oxide remaining in the crude product are removed by vacuum stripping in a small wiped-film evaporator. The degassed crude is then distilled in another wiped-film evaporator at high vacuum to yield pure ethylene carbonate. The bottoms from the product evaporator contain the tetraethylammonium bromide catalyst in solution and are recycled to the reactor system.

Operating Conditions: As described in the above text.



Ethylene Oxide— SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of ethylene oxide.

Charge: High purity ethylene and air or oxygen.

Product: High purity ethylene oxide, liquid.

Description: Compressed air or oxygen, ethylene, and recycle gas are mixed and fed to a multi-tubular, catalytic reactor. The temperature of oxidation is controlled by an organic cooling medium which is omitted on the process flow diagram. From the reactor the effluent gases, which contain ethylene oxide, are cooled and further compressed. The cooling is accomplished first by recuperative exchange with the recycle gases, and finally by a water cooled exchanger. The gases then pass to a scrubber where ethylene oxide is absorbed in a dilute aqueous solution. Most of the unabsorbed gases are returned to the reactor via the previously mentioned recuperative exchanger, thus completing a closed circuit. When air is used as the oxidant, a portion of these gases is diverted to the secondary reactor, to purge accumulated inert gases. The secondary reactor operates to scavenge the remaining ethylene. From the secondary reactor the effluent gases are cooled as before. The ethylene oxide is absorbed in a scrubber, and the residual gases are discharged from the system.

The dilute solution of ethylene oxide is stripped by heat. A feed-bottoms exchanger is usually employed to save steam. The overhead vapor, which contains a substantial amount of water vapor, may be passed through a partial condenser for enrichment. This partial condenser is omitted on the flow diagram, because it is not essential and because of space limitations. Oxide vapor is compressed and refined in a distillation train. There are several alternate arrangements for the distillation. As shown here, the carbon dioxide and other light ends are first stripped out of the oxide, and then pure oxide is distilled away from water and other heavier liquids. The pure ethylene oxide product is pumped as a liquid to storage tanks which are padded with inert gas.

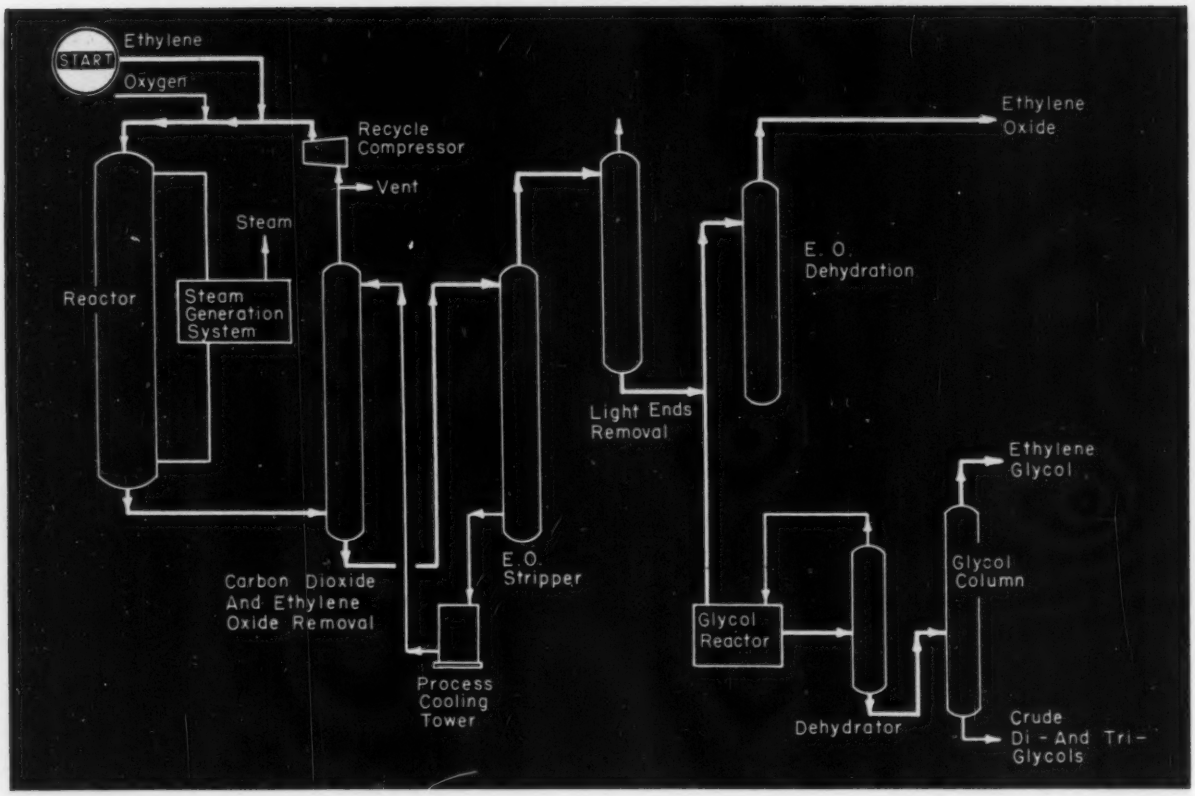
The catalyst contains silver. Its long life and durability make catalyst costs a relatively unimportant item in the ethylene oxide manufacturing budget.

Yields: The weight yield, expressed as pounds of ethylene oxide produced per pound of ethylene consumed, is well over 100 percent in plants of the proper design.

Oxygen Charge: Under certain special conditions (such as in cases where oxygen is required in large quantities for other processes and can be obtained incrementally), SD may recommend its oxygen-based ethylene oxide process as a means of utilizing any prevailing economic advantages incident to the use of oxygen.

Commercial Installations: Thirteen companies now have completed or in design, 20 ethylene oxide plants in seven countries: Naphtachimie, Lavera, France (three expansions); Allied Chemical Corp., Orange, Tex.; Societe Chimique des Derives du Petrole, Antwerp, Belgium (one expansion); Badische Anilin- & Soda-Fabrik (through its subsidiary Chemische Fabrik Holten G.m.b.H., Ludwigshaven, Germany); General Aniline & Film Corp., Linden, N.J.; Houston Chemical Corp., Beaumont, Tex.; Mitsui Petrochemical Industries, Ltd., Iwakuni City, Japan (one expansion); Farbenfabriken Bayer (through its subsidiary Erdoelchemie G.m.b.H., Dormagen, Germany, (one expansion); Marles-Kuhlmann, Gonfreville, France (one expansion); Jefferson Chemical Co., Port Neches, Tex.; Mitsubishi Petrochemical Co., Ltd., Yokkaichi, Japan; Imperial Chemical Industries, Ltd., Severnside, England; and Mo och Domsjo Aktiebolag, Stenungsund, Sweden. Other installations are now in the planning stage.

Reference: PETROLEUM REFINER, Sept. '53, p. 146; *Chemical Engineering*, Aug. '54, p. 130, July 28, 1958.



Ethylene Oxide and Glycol— SHELL DEVELOPMENT COMPANY

Application: The process produces ethylene oxide by direct oxidation of ethylene with 95 percent oxygen. Product distribution between ethylene oxide and glycol can be varied over a wide range.

Charge:

Ethylene		Oxygen	
Ethylene	98% min.	Oxygen	90-95%
Methane	1% max.	Nitrogen	Balance
Ethane	1% max.	Argon	
Acetylene	10 ppm max.		

Products: Ethylene oxide (99.7 percent min.) and ethylene glycol (99.6 percent min.) Description: Ethylene and oxygen together with recycle gas are charged to a tubular isothermal reactor. The reaction takes place in the presence of a silver catalyst and proceeds according to the equation:

$$C_2H_4 + \tfrac{1}{2}\,O_2 = C_2H_4O$$

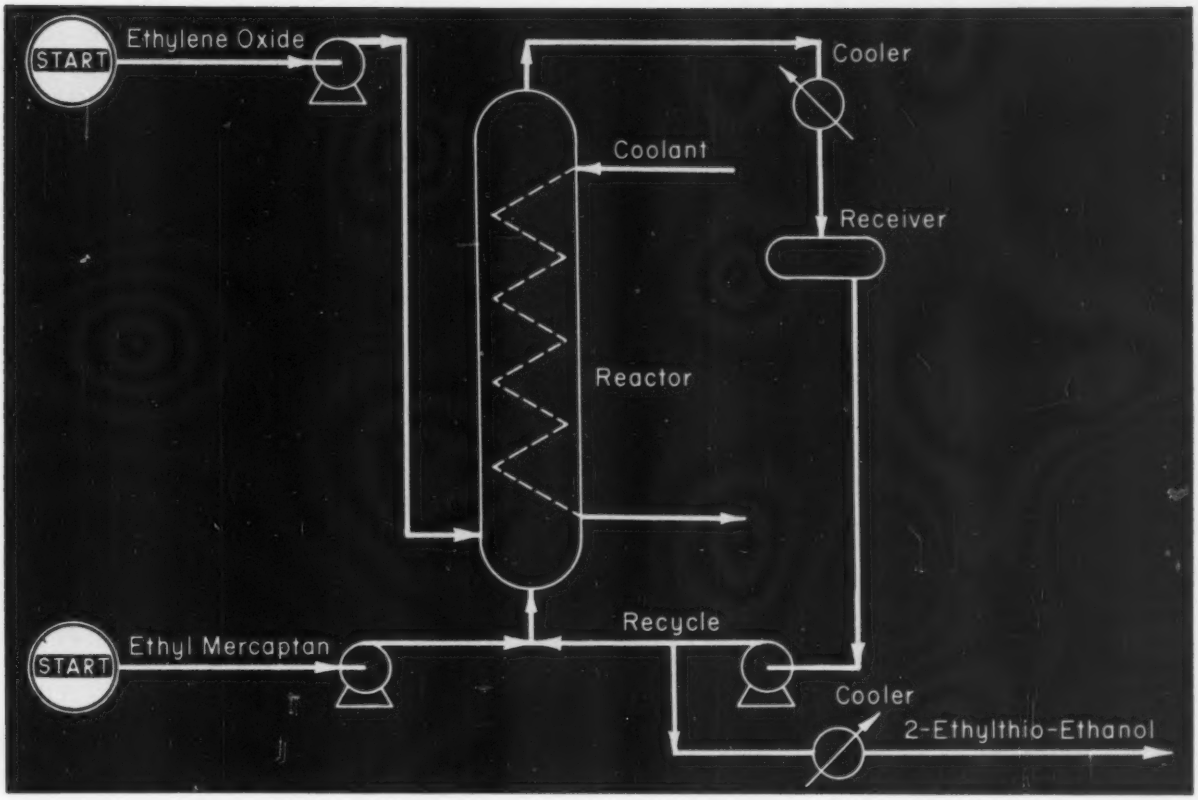
The heat of reaction is removed by a coolant, and the hot coolant is used to generate steam.

Ethylene oxide is recovered from the reactor effluent by absorption in water. Except for a small vent, the residual gases are compressed and recycled. The ethylene oxide is stripped from the "fat" water and distilled to remove light ends. The "lean" water is cooled in a process cooling tower before being returned to the absorber. Part of the raw ethylene oxide is dehydrated to produce finished ethylene oxide; the balance is reacted with excess water in a special reactor according to the equation:

$$C_2H_4O + H_2O = HOC_2H_4OH$$

The resulting aqueous solution of ethylene glycol is dehydrated to produce anti-freeze grade ethylene glycol; industrial grade ethylene glycol and diethylene glycol also may be produced.

Commercial Status: Calcasieu Chemical Corp., Lake Charles, La.; Olin Mathieson Chemical Corp., Brandenburg, Ky.; Petrochemicals Ltd., Manchester, England; and Wyandotte Chemicals Corp., Geismar, La. Under construction: SunOlin Chemical Co., North Claymont, Del. The process is available through the following contractors: Badger Manufacturing Co., Bechtel Corp., Catalytic Construction Co., The Fluor Corp., Ltd., The M. W. Kellogg Co., The Lummus Co., and Stone and Webster Engineering Corp.



Ethylthioethanol — UNION OIL COMPANY OF CALIFORNIA

Application: A process for the manufacture of 2-(ethylthio)-ethanol and other sulfur alcohols.

Charge: Reactants for 2-(ethylthio)-ethanol comprise ethylene oxide and ethyl mercaptan.

Product: High purity 2-(ethylthio)-ethanol suitable as a chemical intermediate without additional purification.

Description: The process may be either batch or continuous. In the continuous process equimolar quantities of ethylene oxide and ethyl mercaptan enter the reactor separately.

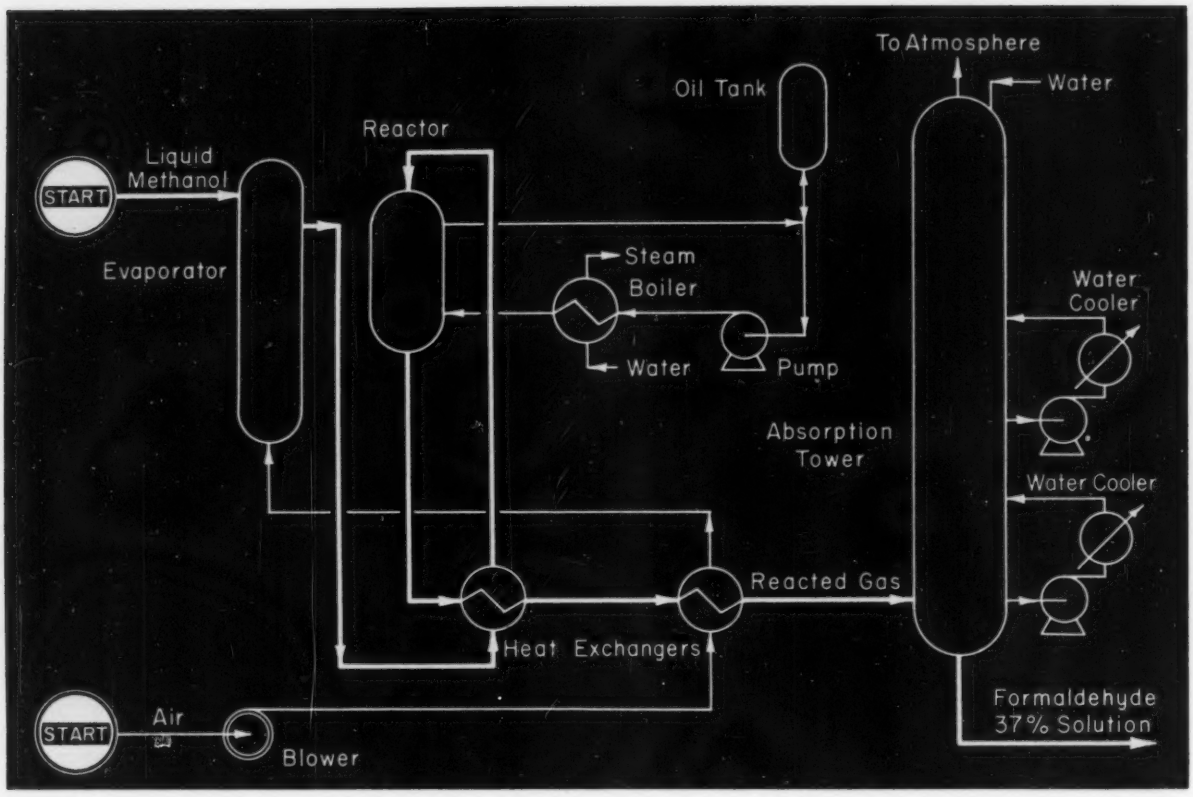
A portion of the reactor product which comprises essentially pure 2-ethylthio-ethanol is recycled to the reactor in the proportion of 1:1 with incoming reactants. Uniquely the presence of the end-product catalyzes the reaction and permits a selective reaction at reduced temperatures. Reaction temperature and pressure are below 200° F and 150 psig respectively.

The beneficial effect which the presence of the product exerts upon the reaction of ethylene oxide with ethanethiol is of important practical significance. This process represents a more economical synthesis than previously experienced.

Yields: Essentially stoichiometric.

References: Preprint Boston ACS Meeting (1959) Sulfur Alcohols from Ethylene Oxide and Thiols.

Doumani, T. F., U.S. 2,776,997 to Union Oil Company of California.



Formaldehyde — MONTECATINI

Application: A process for the manufacture of formaldehyde solution, based on vapor phase catalytic oxidation of methanol by air.

Charge: Rectified methanol (99 percent pure) and atmospheric, non-purified air.

Product: Formaldehyde aqueous solution from 37 to 42 percent by weight, according to desired requirements, containing less than 1 percent by weight of methanol and less than 0.010 percent by weight of formic acid as impurities.

Description: Air, compressed at about 3 psig, is preheated in a first shell-and tube heat exchanger, in which heat from the reacted gases is recovered, and is then conveyed to a methanol evaporator. Feed of methanol is carefully controlled to ensure that the concentration does not exceed 8 percent in the air-methanol mixture.

The mixture leaves the evaporator at about 105 °F. and enters a second shell and tube exchanger, which is also heated by a hot reactor gas stream.

Here the mixture is heated to the desired reactor-feed temperature before entering the converter. Employment of two heat exchangers, one before and one after the vaporizing step, increases recovery of heat from reactor products and requires less exchange surface than a single unit as formerly used.

The air-methanol gaseous mixture flows into the reactor where, in the presence of a special oxidation catalyst composed of metallic oxides, the following basic reaction takes place:

$$2CH_3OH + O_2 \rightarrow 2CH_2O + 2H_2O + 38.06 \text{ Kcal/gmol.}$$

The reaction temperature is controlled to strict limits by a thermostatic oil circulation system. Oil absorbs heat from the reactor and is then cooled in a boiler where the reaction heat is recovered in the form of high pressure steam (280 psig); after cooling, oil is recycled in closed circuit to reactor.

The reacted gases, containing formaldehyde vapors, nitrogen and steam flow through the two heat exchangers and then reach a multistage absorption tower.

This is fed from the top with water. The absorption heat is removed by means of formaldehyde aqueous solutions circulated in a closed circuit, in the first two stages of the tower. Said solutions are cooled in heat exchangers located outside the tower.

The formaldehyde solution produced is directly conveyed to storage tanks and does not need final distillation of excess methanol nor reduction in formic acid content since the process is adjusted to give a high quality product.

Operating conditions: Complete safety against explosion dangers in the gaseous air-methanol mixture is obtained by a suitable choice of mixture components ratio.

Up-to-date control equipment is widely used, so that only one man per shift is needed in running the plant.

A wide range of space velocities can be used, provided the temperature of catalyst and methanol concentrations are kept constant, without impairing formaldehyde yields.

At reduced space velocity, methanol reacts completely, but some CO and CO_2 are formed as byproducts.

At higher space velocities the amount of byproducts decreases but some methanol remains unreacted.

In plant operation, the most suitable conditions are selected in such a way as to ensure that methanol content in the final product is usually kept between zero and 1 percent by weight.

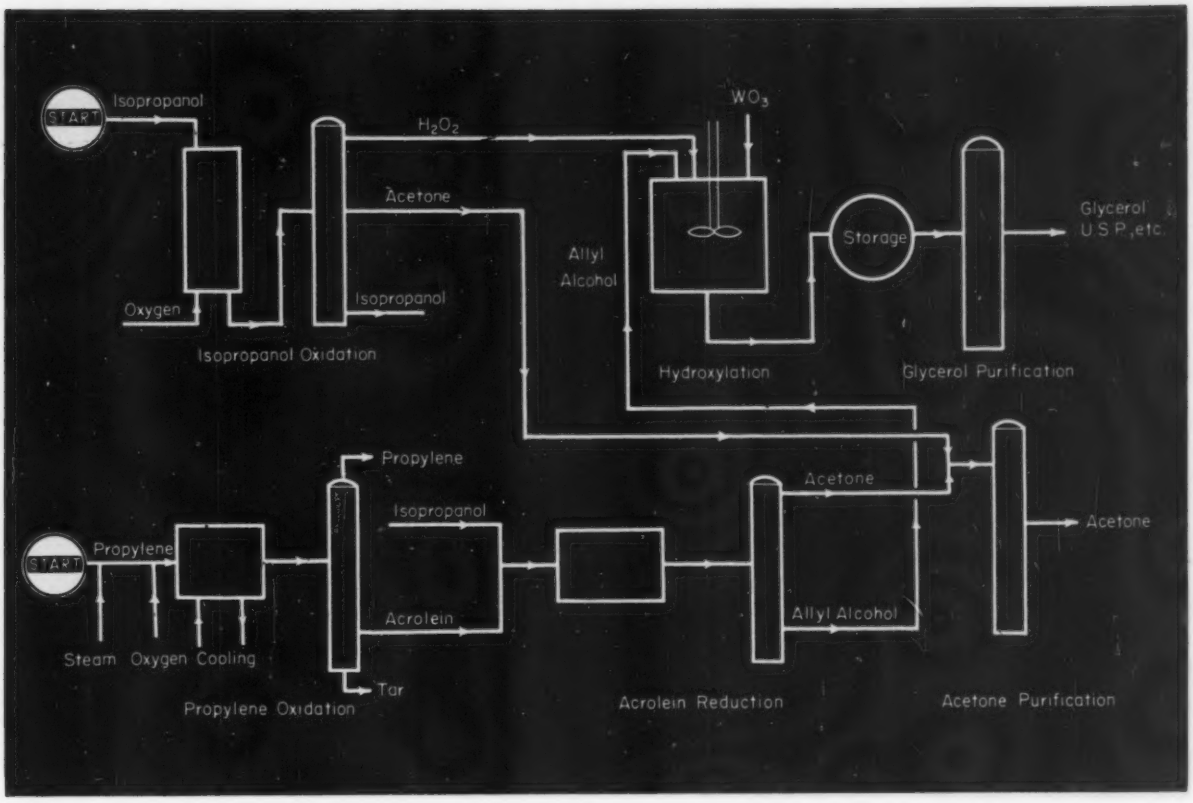
Yields: Over-all yield based on methanol fed is higher than 90 percent on a stoichiometric basis. Heat recovering yields high pressure steam (280 psig), reaching 0.35 metric ton per ton of 37 percent product solution.

High selectivity of the catalyst, prepared by a special process, not only ensures a high purity in the final product, but also allows a long useful life of the catalyst itself (more than 18 months). A specific production of more than 9 metric tons of 37 percent formaldehyde solution for each lb. of catalyst used is standard practice in Montecatini's plants.

Commercial installations: A large industrial plant, composed by four units and having a total capacity of 270 million lbs./year of 37 percent solution is in operation at Montecatini's Works at Castellanza, near Milan, Italy.

Four additional plants of this kind, having a capacity of 55 million lbs./year each are in operation or in advanced construction stage in Belgium, Rumania, The Netherlands and Brazil.

Reference: Chem. & Eng. News, May 26, 1958, p58; Chemical Engineering, Feb. 6th, 1961, p44.



Glycerol (Acrolein and Hydrogen Peroxide)

Application: This is a process for the manufacture of glycerol with large amounts of acetone as a coproduct.

Charge: Propylene, Oxygen.

Description: Propylene is first hydrated to isopropanol using a standard process. (See Page 264). The isopropanol is oxidized in the liquid phase by bubbling pure oxygen through a liquid mixture of isopropanol and H_2O_2 at a pressure of about 2.5 atmospheres and at temperatures between 90° and 140° C. The reaction mixture is diluted with water, stabilized, and fractionated to yield hydrogen peroxide solution, acetone and unreacted isopropanol, which can be recycled.

A mixture of propylene with slightly more than an equal amount of steam is reacted with 25 percent oxygen based on the weight of the propylene. The reaction is carried out over a fixed bed of catalyst based on cuprous oxide, supported on SiC or some other high thermal conductivity support. Close control of reaction temperature is necessary. The reaction pressure may be from 1 to 10 atmospheres and the temperature between 300° and 400° C. The reaction mixture is cooled and fractionated to give acrolein, unreacted proplyene, and tarry by-products. The yield of acrolein is near 86 percent of the propylene consumed.

The purified acrolein is mixed with pure isopropanol from the propylene hydration step and the mixture vaporized. The mixed vapors containing 2-3 moles of alcohol per mole of acrolein are passed through a catalyst bed containing both uncalcined magnesium oxide and zinc oxide, with the magnesia predominating. The reaction takes place at about 400° C and yields about 77 percent allyl alcohol (based on acrolein charged) and an additional quantity of acetone which is added to that formed in the isopropanol oxidation step.

Purified ally alcohol is agitated with a water solution of hydrogen peroxide containing a small amount of tungsten trioxide in solution. The effective catalyst is a 0.2 percent pertungstic acid solution in 2 molar aqueous hydrogen peroxide. The reaction temperature is 60°-70° C, reaction time is about two hours, producing glycerol in water solution.

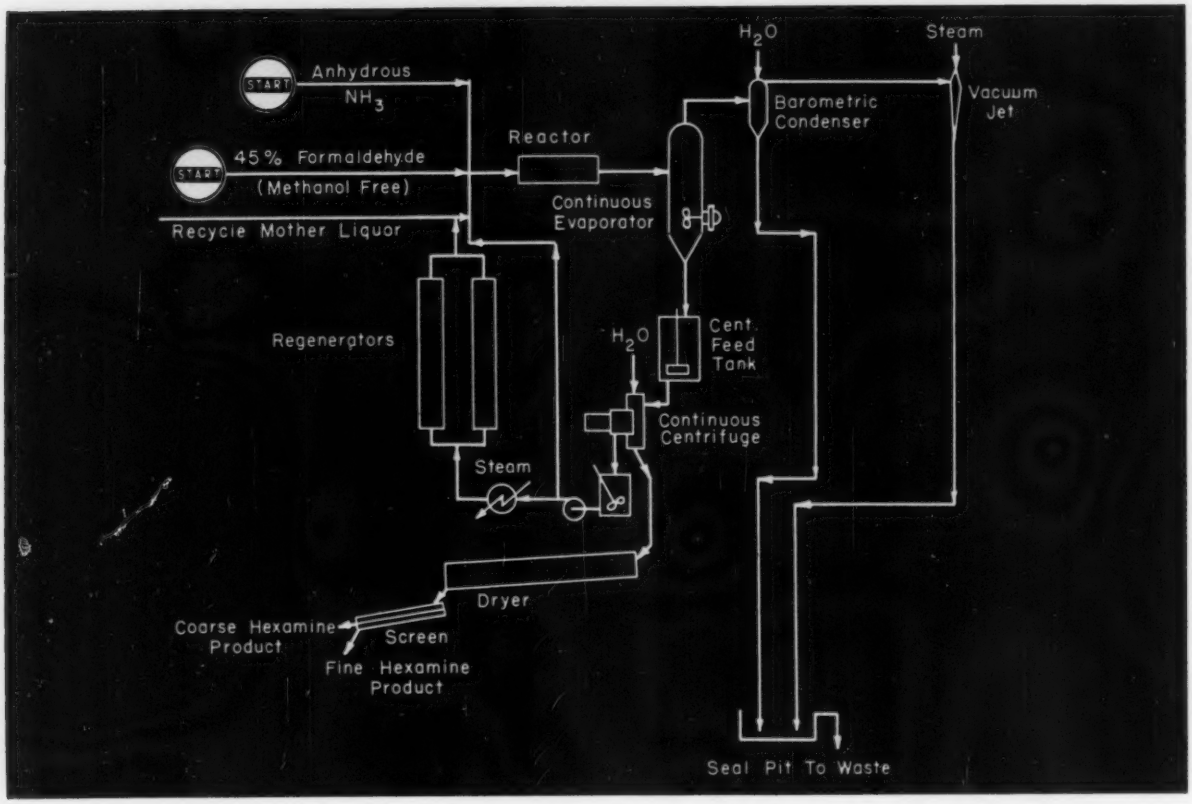
The reaction mixture is dumped to receivers and distilled to yield high-purity glycerol. The recovered catalyst solution is recycled. The yield of the final step 80-90 percent based on the allyl alcohol charged.

Operating Conditions: The control of both the propylene oxidation step and the hydroxylation step must be exceptionally good for acceptable yields. The conditions quoted are approximate, and the practical operating limits are doubtless much less broad.

Yields: The over-all yield of useful products (glycerol and acetone) is not known. The over-all glycerol yield on propylene charged to the oxidation is in the range of 50-60 percent.

Commercial Installations: This process is now in large-scale commercial use by Shell Chemical Co. at Norco, La.

References: Glycerol Payoff in Propylene Parlay, *Chemical Week*, May7,'55,p72-77; S. A. Ballard, H. deV. Finch and E. A. Peterson (to N. V. Bataafsche Petroleum Maatschappij), British Patent 619,014, Mar.2,'49; M. Mugdan and D. P. Young, *J. Chem. Soc.*, 49,2988-3000,CA:43-5269h.



Hexamine — THE LEONARD PROCESS COMPANY

Application: A continuous process for the manufacture of hexamethylene tetramine, $C_6H_{12}N_4$.

Charge: Technical grade anhydrous ammonia and 45 percent methanol free formaldehyde.

Product: Coarse or fine hexamethylene tetramine crystals.

Description: Technical grade anhydrous ammonia, 45 percent methanol free formaldehyde, and recycle mother liquor are fed continuously at controlled rates to a high velocity reactor. Since the reaction is exothermic, the flow of recycle liquor is kept high enough to keep the reaction temperature below the decomposition temperature of the hexamine, but by discharging the reactor effluent directly into the vacuum evaporator, the heat of reaction supplies the bulk of the heat needed to drive off the water of reaction. When sufficient water is removed, the hexamine crystallizes from solution so that the continuous evaporator serves both as evaporator and crystallizer. Slurry from the evaporator is fed to a continuous centrifuge (washing type) which separates the hexamine crystals and discharges them to a rotary dryer, and then to a vibrating screen for separation into fine and coarse crystalline product. The mother liquor and wash water from the centrifuge are pumped back through the continuous reactor. A small side stream of this mother liquor is continuously pumped through a regenerator system to remove byproduct impurities and prevent building up such impurities in the system.

The entire operation is continuous and is controlled by instruments so that one operator per shift controls the plant except for product packaging which requires one packer per day.

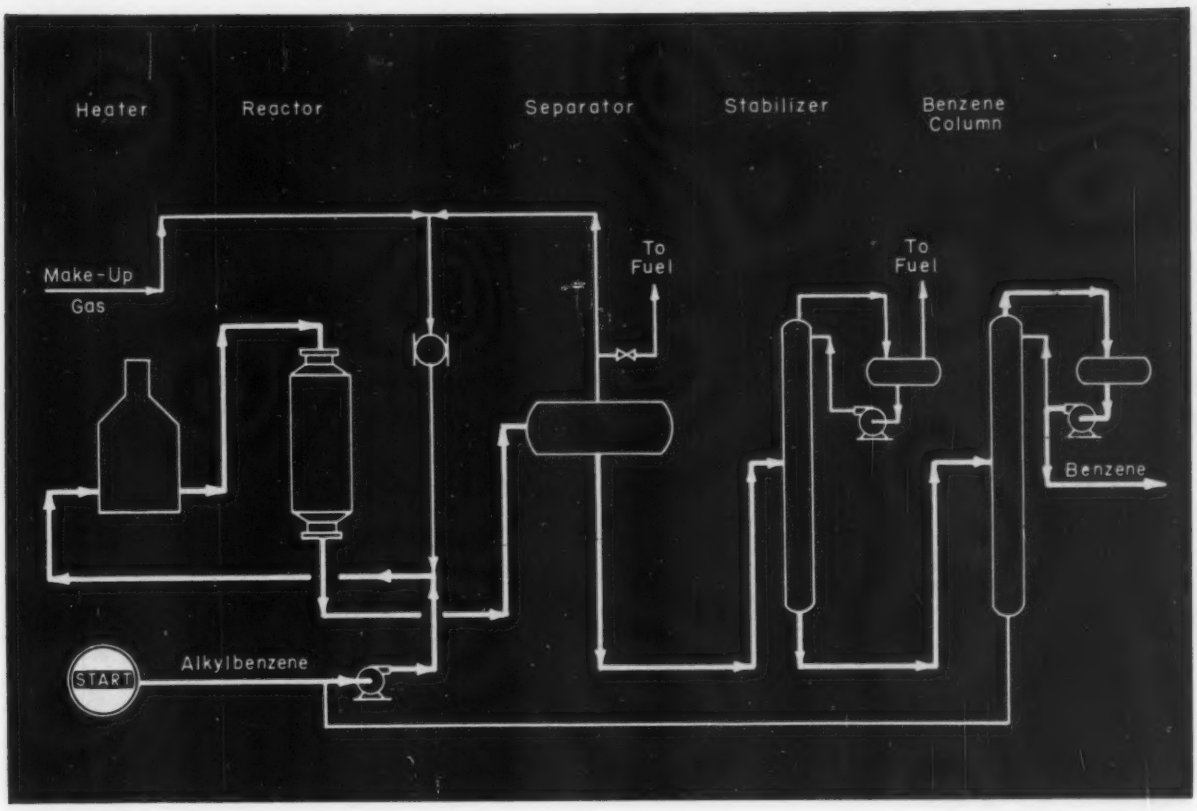
High yields and minimum byproduct formation are accomplished by careful control of reactor temperature, pH, and concentration.

All process equipment in contact with the hexamine solution or product is fabricated of stainless steel to keep the product pure and free of color.

Yields: Over-all yield of both ammonia and formaldehyde is above 96 percent.

Commercial Installations: The continuous process has been developed from operating data and experience with the various Ordnance Works that produced Hexamine during the last war for the manufacture of RDX explosive. The Ordnance Works utilized a batch operation and made no attempt to utilize heat of reaction. Several continuous plants are now in operation in Europe.

Reference: PETROLEUM REFINER, Sept.,'58,p.351.



Hydeal—UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for the catalytic dealkylation of toluene or C_9 aromatics to produce benzene. Other applications include the dealkylation of alkylnaphthalenes to naphthalene.

Charge: Toulene or C_9 aromatics (alkylbenzenes), either pure or in a mixture with other hydrocarbons, and a hydrogen-containing gas, in the example shown.

Products: Nitration-grade benzene and/or naphthalene, depending on the charge composition.

Process Description: The hydrodealkylation of toluene to benzene is described for illustration. Fresh and recirculating hydrogen are combined with fresh and recycle alkylbenzenes. The hydrogen may be obtained from off-gas from a reforming unit to yield sulfur-free products.

The combined feed is brought to reaction temperature and charged to the reactor. Alkylaromatics are converted to benzene in accordance with the equations:

$$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$$

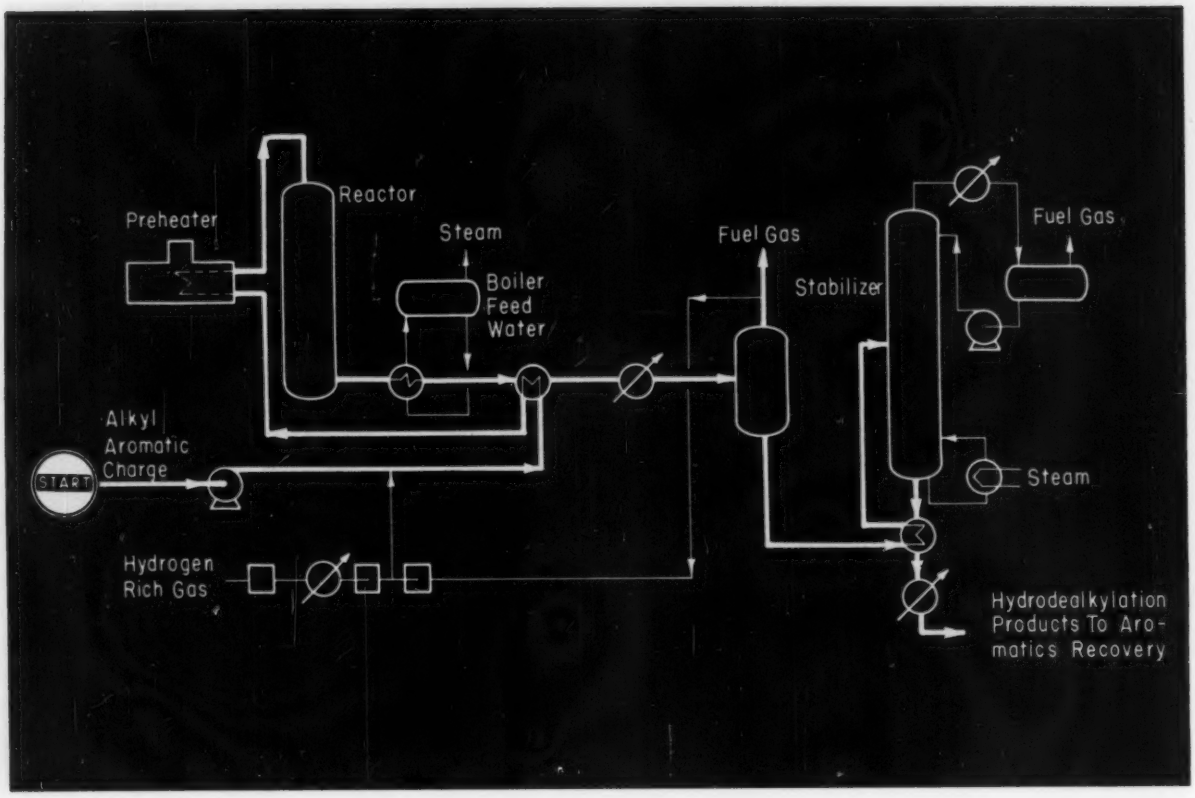
$$C_6H_4(CH_3)_2 + 2H_2 \rightarrow C_6H_6 + 2CH_4$$

Reactor effluent is cooled and charged to the separator, from which hydrogen is taken and recycled to the reactor. The liquid from the separator passes to the stabilizer for stripping of hydrocarbons boiling lower than benzene. Better than nitration-grade benzene is taken overhead from the final column, and the bottoms are recycled to the reactor for dealkylation.

Yields: Yields of benzene from the hydrodealkylation of alkylbenzenes are about 95 percent of theoretical; yields of naphthalene are essentially stoichiometric, based on precursors in the charge stock.

Licensing: The process was jointly developed by Ashland Oil & Refining Co. and Universal, and licensed by Universal under patent rights of both companies.

Commercial Installations: Several commercial units are in operation producing benzene; one produces naphthalene plus benzene. A number of other units are in the design or construction stages.



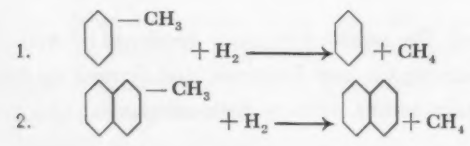
Hydrodealkylation — THE ATLANTIC REFINING COMPANY HYDROCARBON RESEARCH, INC.

Application: A process for producing benzene, naphthalene, and other selected aromatics at required purities.

Charge: The process may use alkyl aromatic rich charge stocks obtained from cracking, reforming, pyrolysis, or coal tar operations.

Products: High purity benzene and naphthalene.

Description: The process involves the hydrodealkylation of alkyl aromatics to simple aromatics and gas. Using toluene and methyl naphthalene as feedstocks, the principal reactions are:



Hydrogen rich makeup gas and recycle gas are compressed and mixed with the liquid alkyl aromatic charge. The combined feed is preheated first by heat exchange and finally in a fired preheater for charge to the reactor. Leaving the reactor, the product mixture is cooled by generating steam, by heat exchange with reactor feed, and finally by cooling water. The cooled reaction product is next separated into gas and liquid fractions. A portion of the gas is recycled to the reaction system. The remainder of the gas is removed as fuel gas product. The separator liquid is charged to a stabilizer tower after first preheating with stabilizer bottoms. Fuel gas is removed overhead from the stabilizer. The bottoms product containing the aromatics is cooled and passes to an aromatics recovery unit which may be integral with the hydrodealkylation unit.

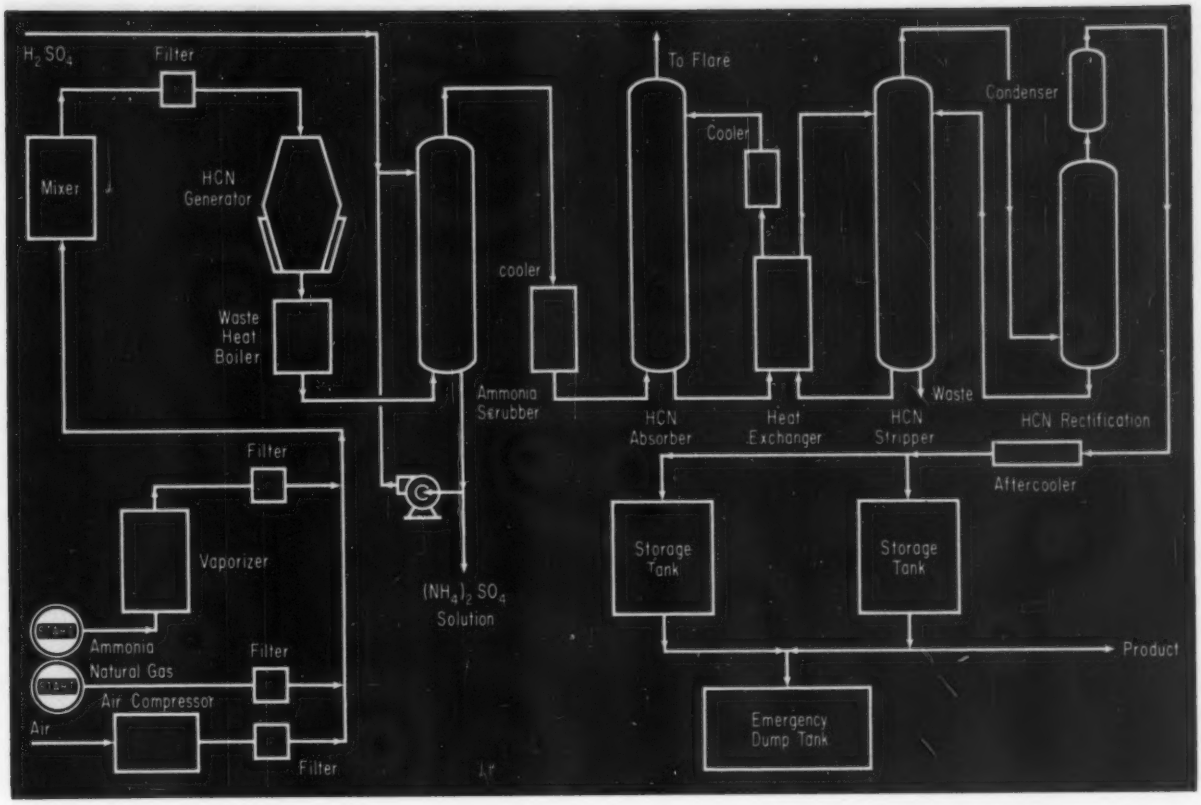
Usual Operating Condition:

Temperature	1,100-1,400° F
Pressure	500-1,000 psig

Yields: Yields may be expressed as percent of theoretical. Yields of benzene from toluene are 98 percent or more. Yields of naphthalene from dicyclic aromatics are in excess of 90 percent of theoretical.

Commercial Installations: Two units are building and two additional units are in the planning stage.

NOTE: This process includes certain technical information and rights under patents of Esso Research and Engineering Co.



Hydrogen Cyanide (Andrussow Process)— GIRDLER CORPORATION

Application: A process applied to the manufacture of hydrogen cyanide. The reactor gas may also be used to produce alkali cyanides by absorbing hydrogen cyanide in caustic.

Charge: Natural gas and anhydrous ammonia are the charge.

Product: The product is 98.5 percent liquid hydrogen cyanide and 1.5 percent water.

Description: Hydrogen cyanide is produced by the reaction of ammonia, natural gas and air over a platinum catalyst and may be represented as follows:

$$NH_3 + CH_4 + 1.5\,O_2 \rightarrow HCN + 3H_2O$$

Ammonia and natural gas, under at least 5 to 10 psig pressure, are filtered and mixed prior to entering the converter vessel. The converter operates at 1,800° F. and pressures slightly above atmospheric. The approximate composition of the effluent gas is given below:

Composition of Gas Produced in Generator	Mole-Percent
Hydrogen cyanide	5.9
Ammonia	1.6
Carbon dioxide	0.2
Carbon monoxide	4.4
Methane	0.5
Hydrogen	7.5
Oxygen	0.1
Nitrogen	56.7
Water vapor	23.1
	100.0

The effluent gases are cooled immediately in a waste heat boiler which produces 150 psig steam used in the process. The boiler is specially designed to avoid decomposition of the hydrogen cyanide.

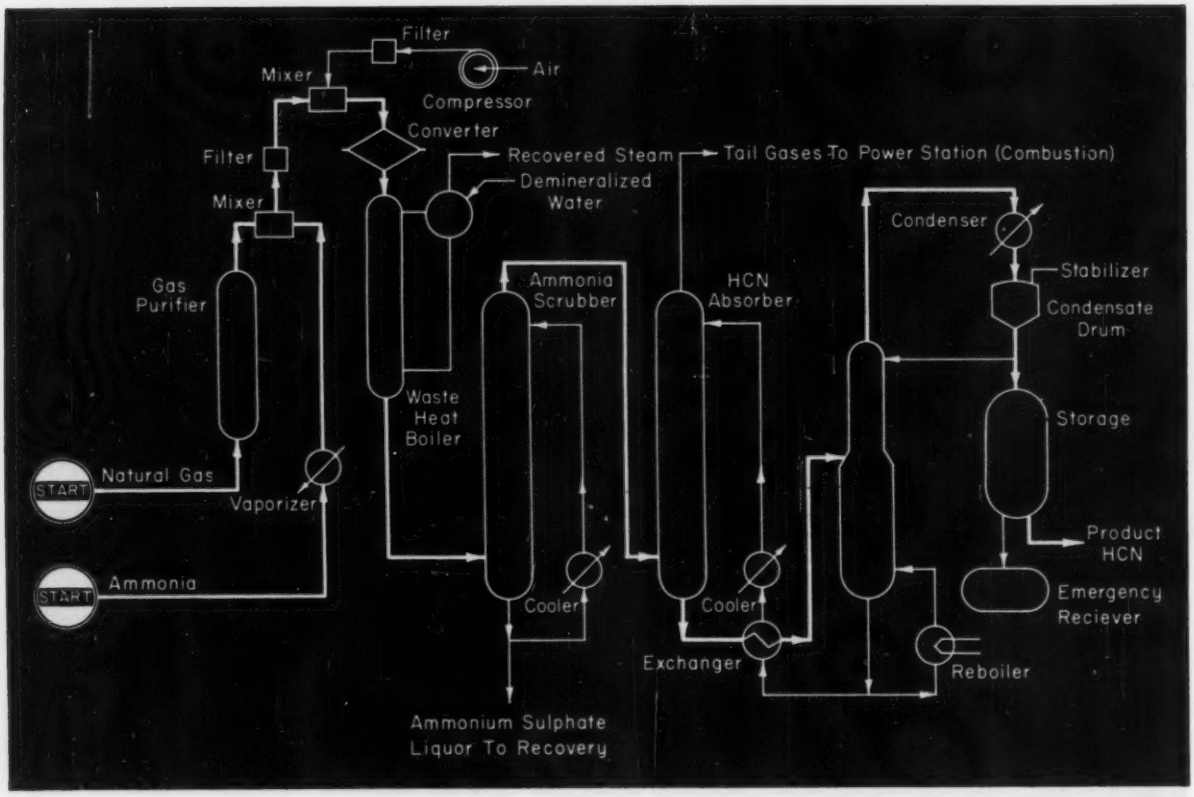
Following the waste heat boiler the gases are washed with a dilute sulfuric acid-ammonium sulfate solution to remove unreacted ammonia from the reactor gases, and thus avoid formation of hydrogen cyanide polymers in the absorption and recovery system. The ammonium sulfate thus produced may be concentrated to produce crystalline ammonium sulfate or added to fertilizer solutions.

Following the ammonia scrubber, the gases are cooled and passed through a column where hydrogen cyanide is absorbed in water. The residual gases are flared and discharged to the atmosphere. The hydrogen cyanide is stripped from the water solution, rectified and liquefied. Suitable vapor and liquid phase inhibitors are used to avoid polymerization and stabilize the final product.

Yields: 63 to 70 percent of the ammonia is converted to HCN depending on operating conditions. Approximately half of the remaining ammonia is recoverable as byproduct ammonium sulfate.

Commercial Installations: A commercial operation having a capacity of approximately 20 million pounds per year has been in operation for a number of years.

References: PETROLEUM REFINER, Vol. 32, No. 9, Sept. 1953, p 197.



Hydrogen Cyanide — MONTECATINI

Application: A process for manufacturing liquid hydrogen cyanide, anhydrous.
Charge: Natural gas and anhydrous ammonia.
Product: Liquid hydrogen cyanide 99-99.5 percent pure, containing less than 0.5 percent of water.
Description: Hydrogen cyanide is produced by means of partial combustion, under pressure, of natural gas and ammonia in presence of air over platinum as a catalyst.

Catalysis gases have the following average composition:

Component	Volume Percent
Hydrogen cyanide	7.5
Ammonia	2.5
Water	24.1
Carbon dioxide	0.9
Carbon monoxide	3.2
Oxygen	0.1
Hydrogen	7.6
Methane	0.4
Nitrogen	53.7
	100.0

The reaction may be represented as follows:

$$NH_3 + CH_4 + 1.5O_2 \rightarrow HCN + 3H_2O$$

Natural gas, essentially methane, is carefully purified from every sulphur impurities and then mixed with ammonia flowing from an evaporator.

The compressed air is added, prior filtration, to methane and ammonia. The gaseous mixture is passed to the reactor.

The reaction takes place at a temperature of 1200° C and at the same pressure under which the absorbing phase is occurring. The gases effluent from the reaction phase are quickly cooled in a waste heat boiler producing the steam used in the process.

Following the waste heat boiler, the catalysis gases are washed with a dilute sulphuric acid solution in a scrubbing tower to remove unreacted ammonia.

The ammonium sulfate solution thus obtained as a byproduct, after being freed of dissolved HCN, is sent to a concentration unit. The HCN, neutralized with sulfuric acid is then separated from the catalysis gases by a counter-current washing with water, stabilized to prevent polymerization of the hydrogen cyanide.

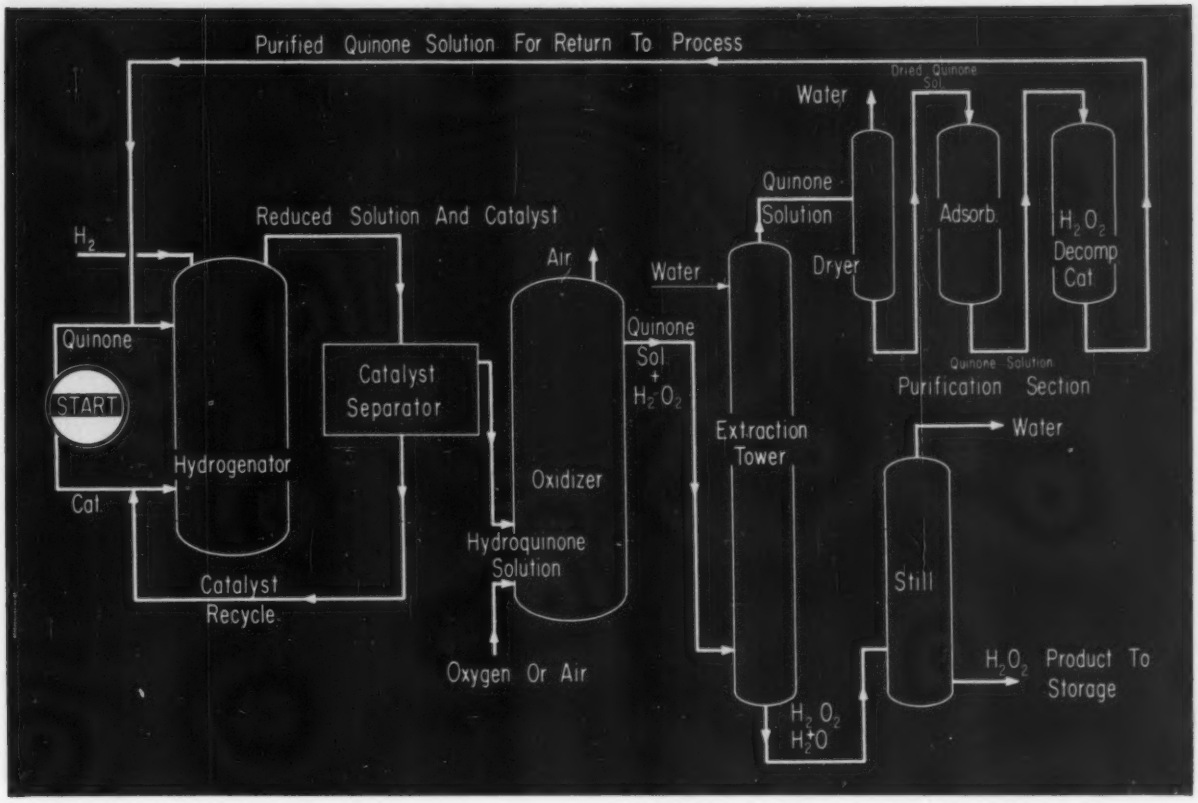
The tail gases are sent to the power station where they are flared in order to eliminate the residual hydrogen cyanide (less than 0.1 percent in volume) and recover the combustion heat. The hydrogen cyanide is stripped from the water solution in a rectifier from which hydrogen cyanide is obtained as a top product having a water content lower than 0.5 percent while the absorbing solution is recovered at the bottom with a hydrogen cyanide content lower than 0.1 percent. The later is cooled and then sent to the head of the absorbing tower.

Hydrogen cyanide produced is stabilized by adding acetic acid at a rate of 0.3 percent approx.

Suitable vapor and liquid phase inhibitors are used to stabilize the hydrogen cyanide present in the various steps of the process.

A small product storage is performed, as hydrogen cyanide, is directly sent to the various end uses.

Operating Conditions: Given in the above text.
Yields: About 65 percent of methane and 70 percent of ammonia are converted to HCN; approximately 20-25 percent of the starting ammonia is recovered as ammonium sulfate (by-product).
Commercial Installation: A plant for the production of hydrogen cyanide, to be all transformed in methacrylic ester, is in operation at the Montecatini Factory of Rho (Milan). The construction of a new plant for the production of hydrogen cyanide, intended to be converted also in derivates, and having a much higher capacity than the present one, is planned.



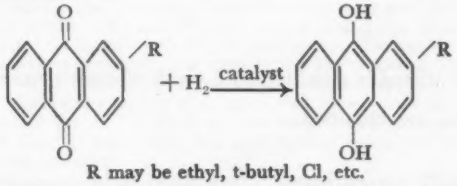
Hydrogen Peroxide— BECCO CHEMICAL DIV., FMC CORP.

Application: A non-electrolytic process for manufacturing hydrogen peroxide.
Charge: An alkylated anthraquinone, quinone and hydroquinone solvents, catalyst, hydrogen, air or oxygen, water.
Product: Aqueous hydrogen peroxide of 15-35 percent concentration by weight.
Description: The process consists of reducing anthraquinone to hydroquinone, oxidation back to quinone with hydrogen peroxide production, extraction of hydrogen peroxide, and purification of process solution for recycle.

The alkylated anthraquinone, usually 2-ethyl or 2-tertiary butyl anthraquinone, is obtained from Friedel-Crafts reaction of phthalic anhydride or ethyl (or tertiary butyl) benzene.

The working solution (anthraquinone in solvent) is fed to the hydrogenator and reduced to the hydroquinone stage with hydrogen and catalyst. Solvents may be—aromatic hydrocarbons, alcohols, ketones, esters, etc.—which maintain the quinone and hydroquinone in solution.

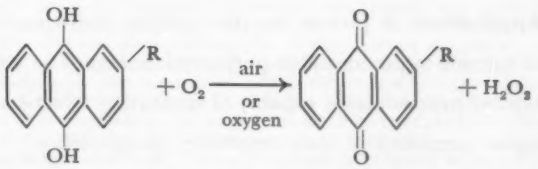
Hydrogenation is at room temperature to 40 C or more and hydrogen pressure of 1-3 atmospheres. Catalysts may be Raney nickel, nickel, palladium or platinum. Hydrogenation is less than theoretical to avoid hydroquinone precipitation and the formation of nuclear hydrogenated products. The main hydrogenation reaction is as follows:



R may be ethyl, t-butyl, Cl, etc.

Catalyst is removed from the hydrogenated solution by filtration or centrifugation and recycled. Catalysts used also decompose hydrogen peroxide and reduce yields in the oxidation step.

The hydroquinone solution then passes through a series of air or oxygen oxidizers. The hydroquinone is reconverted to quinone and hydrogen peroxide formed, as shown below:



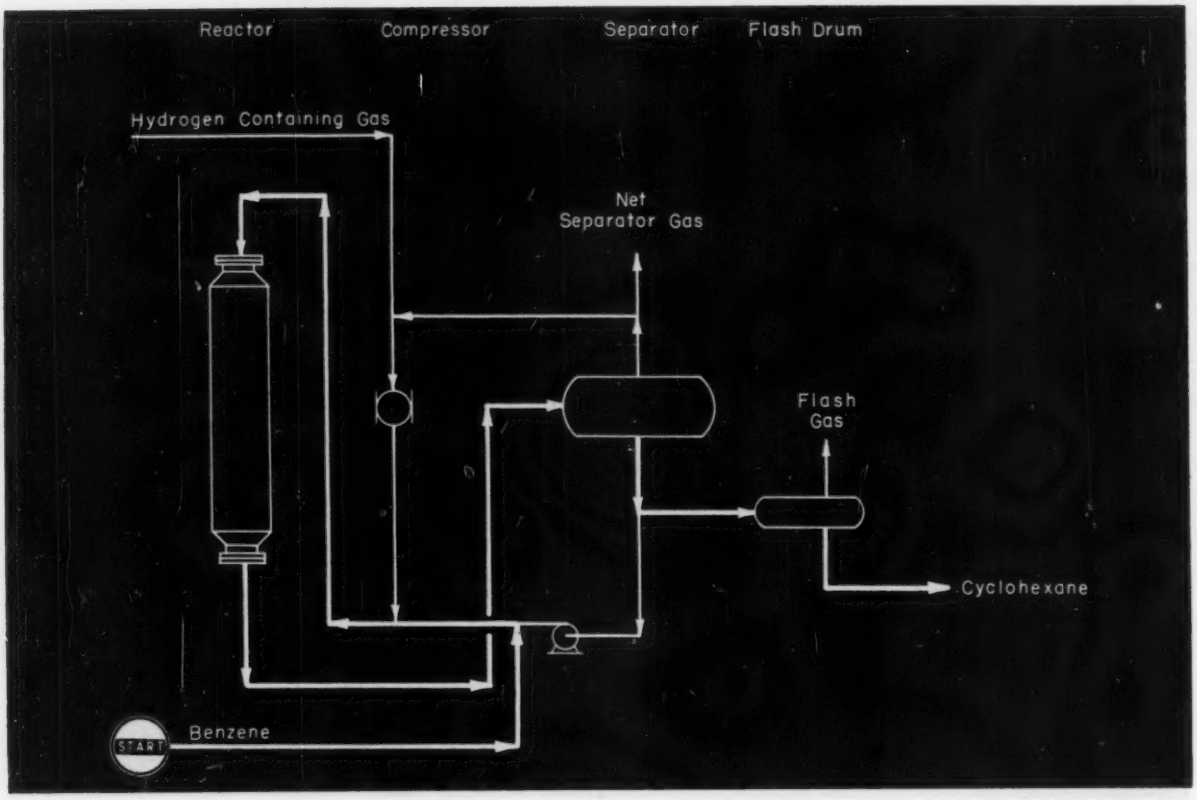
The oxidized solution (½-1 percent hydrogen peroxide) is extracted, the hydrogen peroxide-rich organic solution rising countercurrent to the top entering water. The solvents used must yield operable density gradients and partition coefficients for hydrogen peroxide between aqueous and organic phases. Density gradients are 0.05-0.1 g/cm³. The extractors operate at 25-40 C. and yield 15-35 weight percent hydrogen peroxide. This solution goes to storage or to vacuum stills for concentration to any desired strength.

The organic phase, leaving the final extractor, is separated from entrained water and partially dried. Traces of hydrogen peroxide, if harmful to the catalyst, are removed by catalytic treatment before the work solution is recycled. A typical cycle requires 2-4 hours. A plant producing 100 lbs./hour of hydrogen peroxide (100% basis) may require 20,000-50,000 lbs. of work solution.

Operating Conditions: The principal operating conditions given above are influenced by the solvent, catalyst, etc.
Yields: The yield of hydrogen peroxide has been reported as 90 percent of the theoretical, based on hydrogen consumption.

Commercial Installations: This process, or a variation thereof, is reputedly used in plants of the following U. S. companies: Becco Chemical Division, FMC Corp., New York; Pittsburgh Plate Glass Co., Barberton, Ohio; E. I. duPont de Nemours & Company, Wilmington, Del.; and Solvay Process Division, New York, N. Y.

References: Kirk-Othmer "Hydrogen Peroxide," p 418, First Supplement (1957), Encyclo. Chem. Technology, Interscience Encyclo. Co., Inc. New York. *Chemical Week,* p75,No.5(1955). The *Industrial Chemist,* Jan.'59.



Hydrar— UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for the catalytic hydrogenation of benzene to produce high-purity cyclohexane. The UOP Hydrar process also is capable of converting toluene and higher aromatics to their respective cycloparaffins.

Charge: Benzene and a hydrogen-containing gas.

Product: The purity of the cyclohexane product is a function of the purity of the benzene feed. If the benzene is 99.8+ percent pure, as is the case when it is produced by a Udex unit, the cyclohexane will have a freeze point of 6.0° C, indicative of comparable purity.

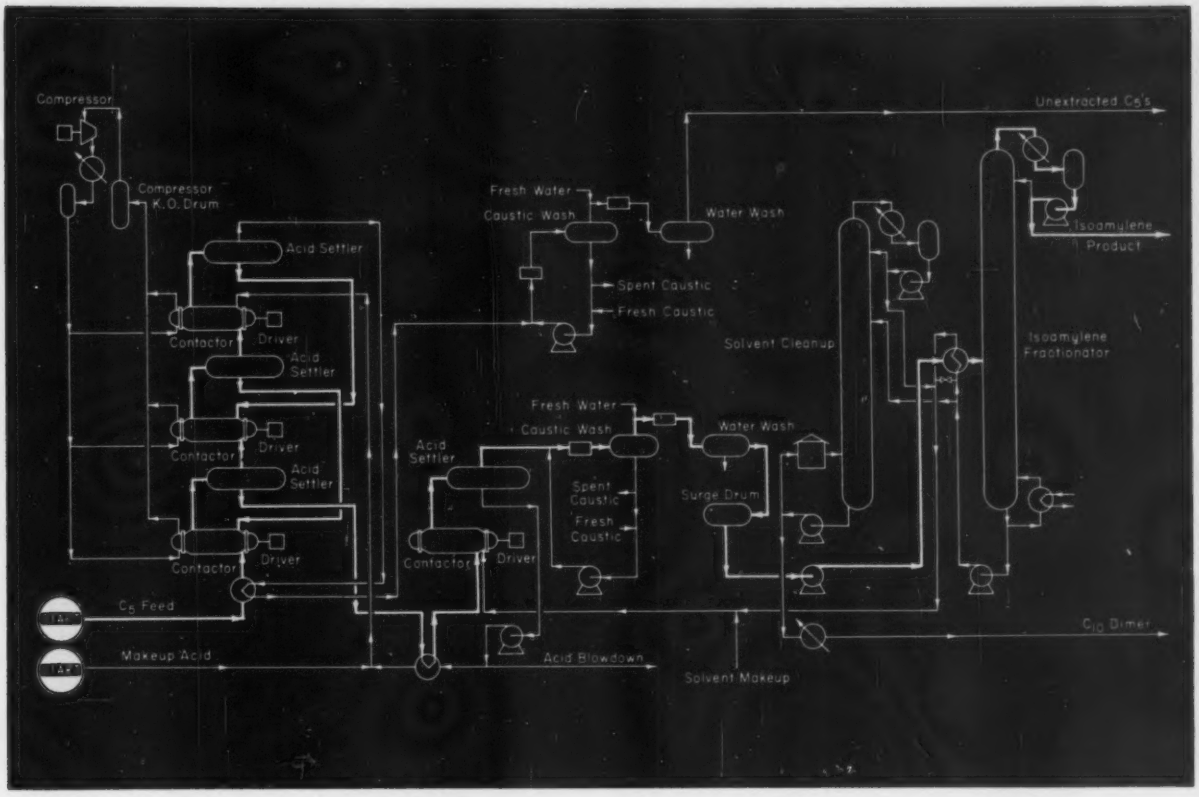
Process Description: Benzene feed, recycle cyclohexane and fresh and recycle hydrogen are brought to reaction temperature and charged to the reactor. The conversion of benzene to cyclohexane is stoichiometric. The reactor effluent, after exchanging heat with the feed, is charged to the separator. Gas from the separator is recycled to the reactor, a small net gas stream being removed.

A portion of the cyclohexane from the separator is recycled to the reactor to assist in the control of the reaction temperature. Product cyclohexane is flashed and/or stabilized to remove light hydrocarbons.

Operating Conditions: Operating conditions are moderate, allowing the use of conventional equipment throughout the plant.

Yield: Virtually stoichiometric yields of cyclohexane from benzene are obtained.

Commercial Installations: Two Hydrar units are presently in operation. Several others either are licensed for construction or are under consideration.



Isoamylene (Sinclair Process) — STRATFORD ENGINEERING CORPORATION

Application: A process for the selective extraction of isoamylenes.
Charge: The pentane fraction from gasoline produced in catalytic cracking.
Product: Isoamylenes of 97+ percent purity.

Description: Isoamylenes are selectively extracted with sulfuric acid from the pentane fraction of gasoline produced in catalytic cracking. The process uses 65 weight percent sulfuric acid for the selective absorption of the isoamylenes to produce a "fat" acid. The isoamylenes are recovered from the "fat" acid by contacting with a paraffin hydrocarbon. Isoamylenes are recovered from the paraffin solvent by simple distillation.

The pentane fraction recovered from a typical gasoline produced by catalytic cracking contains approximately 3.5 percent 3-methylbutene-1, 10.5 percent 2-methylbutene-1, and 21.0 percent 2-methylbutene-2. Sulfuric acid readily absorbs the second two isomers but does not absorb the 3-methylbutene-1. Absorption is accomplished by single or multiple countercurrent, mixer-settler extraction stages in a forward extraction section. Economic considerations normally indicate little advantage for more than three stages. The exothermic heat of absorption is removed by exchange with a closed circuit refrigeration system. Isoamylenes are removed from the acid by contacting the "fat" acid with an inert paraffin solvent, preferably containing six to nine carbon atoms, in a back extraction stage. The endothermic heat of desorption is supplied by the sensible heat in the feeds to the back extraction stage. The acid from the back extraction stage, containing only a few percent of the isoamylenes, is recycled to the forward section. The paraffin solvent containing the isoamylenes is caustic and water washed and sent to the distillation section for isoamylene recovery. The unexpected hydrocarbons are caustic and water washed and returned to the gasoline pool.

The distillation section consists of two towers, the isoamylene fractionator for and a small solvent cleanup tower. Separations are not difficult since there is a wide boiling point difference between the products.

Isoamylene product purity is 97+ weight percent. This purity is established by C_5 hydrocarbon entrainment in the "fat" acid and the separation obtained between isoamylenes and solvent in the distillation system. A vacuum flash can be used to remove entrained C_5's from the "fat" acid and the distillation section design specifications can be tightened to produce a product of 99+ weight percent purity. The ratio of 2-methylbutene-2 to 2-methylbutene-1 in the product is approximately 9:1. In the presence of sulfuric acid, isomerization occurs and approximately this ratio of the isomers is produced even though the ratio in the feed is normally only about 2:1.

Dimerization of isoamylenes to decene isomers occurs in all stages of the process where the isoamylenes are in contact with sulfuric acid. The amount of dimer formed is a function of the temperature, time of contact with the acid, and the concentration of isoamylenes in the acid streams. These conditions are controlled so that excessive dimer production is avoided.

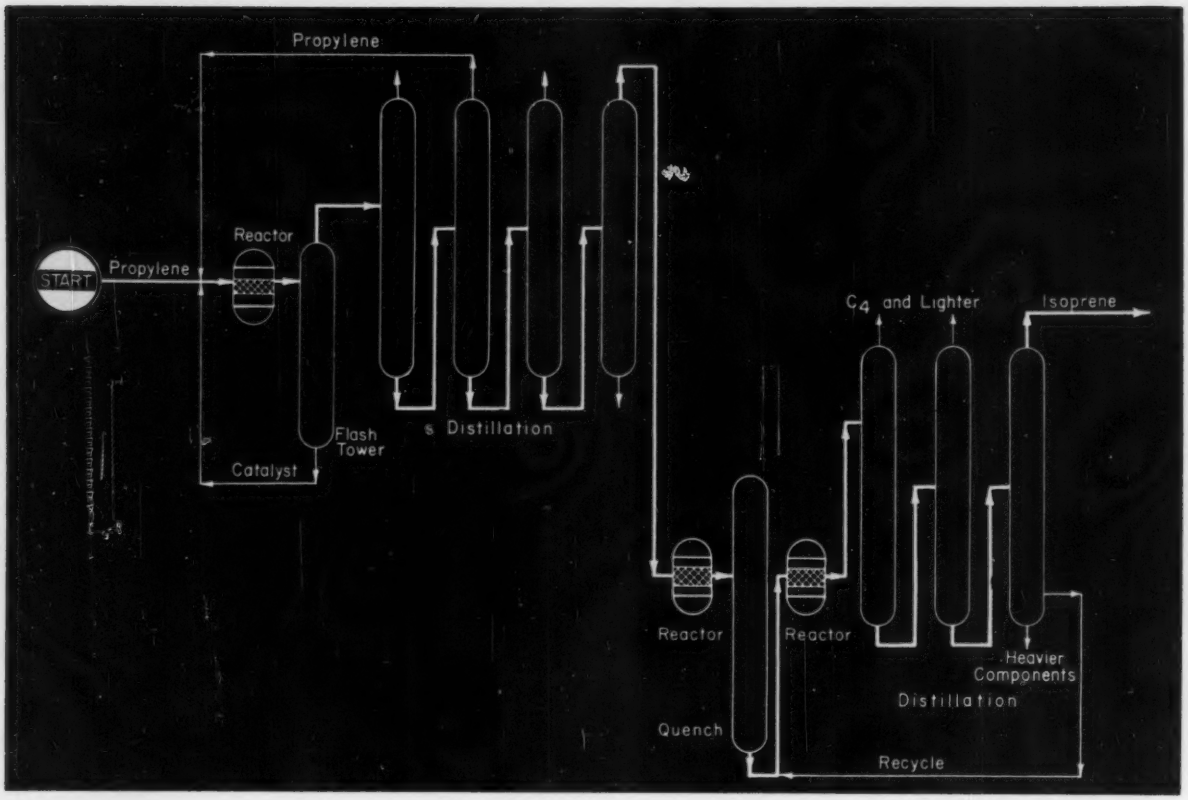
Operating Conditions: The major operating variables in the process are acid and solvent rates, forward and back extraction temperatures, extractor efficiency or approach to equilibrium, and extractor and settler holdup time. Forward extraction is optimum between 32° and 50° F, and back extraction between 80° and 90° F. Recovery of isoamylene produce is approximately 65 percent, 78 percent and 85 percent for one, two and three stage forward extraction stages.

Yields: Typical yields for the process using three-stage forward, one stage back extraction are as follows:

Component, Weight Percent	Feed	Isoamylene Product	Dimer Product
C4's	1.0	....	....
3-Methylbutene-1	3.5	Trace	....
Isopentane	30.0	1.2	....
n-Pentane	9.0	0.1	....
Pentene-1	5.0	Trace	....
2-Methybutene-1	10.5	8.6	....
Pentene-2 (C & t)	18.0	0.3	....
2-Methybutene-2	21.0	88.8	....
Pentadienes	Trace	....	....
Hexanes	2.0	....	....
Solvent	....	1.0	1.0
Dimer	....	....	99.0
	100.0	100.0	100.0

Commercial Installations: A small, two-stage forward extraction, one-stage back extraction, pilot plant producing one barrel per day isoamylene product has been operated by Stratford Engineering Corporation in its laboratory at Kansas City, Missouri.

Reference: R. L. Foster, D. K. Wunderlich, S. H. Patinkin, R. A. Sanford, "New Process for Pure Isoamylenes," PETROLEUM REFINER, 39, No. 11, 229-32, 1960.



Isoprene—THE GOODYEAR TIRE & RUBBER CO. AND SCIENTIFIC DESIGN CO., INC.

Application: A process for the manufacture of high purity isoprene.

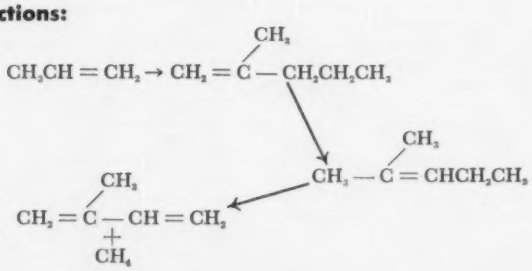
Charge: Propylene.

Product: Polymerization grade isoprene suitable for use with stereospecific catalyst systems.

Description: Incoming propylene, mixed with tripropyl aluminum catalyst, is compressed and heated, then passed to the reactor. Reactor effluent passes directly to the flash tower, which separates the catalyst and a heavy hydrocarbon carrier as bottoms for recycle. The top products, 2-methyl-1-pentene, propylene, and light hydrocarbons, are sent to distillation. Purified 2-methyl-1-pentene, recovered as top product from the distillation apparatus, is heated and passed through a fixed bed of solid acid-type catalyst. Effluent from this reaction is passed to a distillation tower where unreacted 2-methyl-1-pentene is recovered as top product. Isomerized 2-methyl-2-pentene is recovered as bottoms and sent to a surge tank, where it is mixed with hydrogen bromide catalyst. The mixture is pumped to the pyrolysis furnace and heated in the presence of added steam. Furnace effluent is passed through quenching, demethanization, light hydrocarbon stripping, then to isoprene purification in a final distillation tower. Here, polymerization-grade isoprene is taken off as top product, and heavier hydrocarbons are removed as bottoms.

Alternate Catalyst. An alternate catalyst system is available for the continuous vapor phase dimerization of propylene at costs and yields comparable to those provided by the aluminum alkyl catalyst.

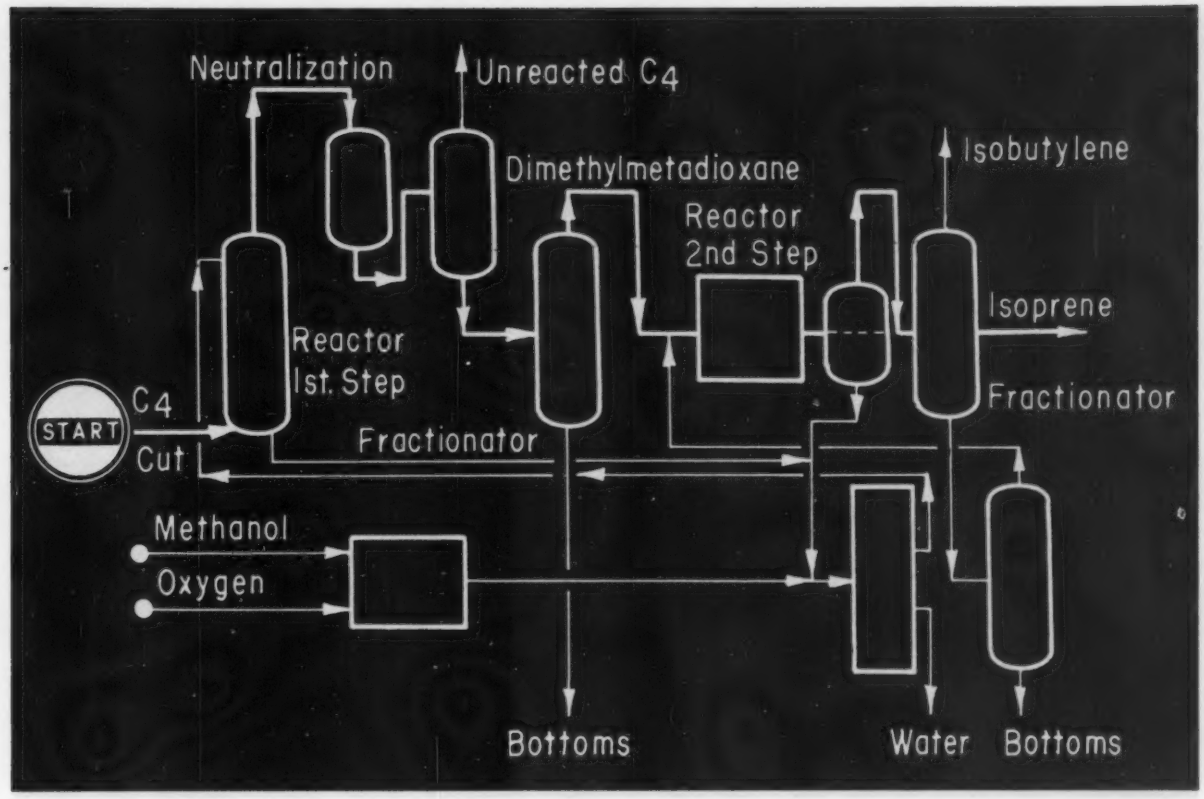
Reactions:



Economics: Production costs involved in the Goodyear-SD isoprene process are so low that polyisoprene made from the monomer is fully competitive with natural rubber, in cost as well as in performance. Moreover, an integrated monomer-polymer plant using this process requires a considerably lower capital investment than an integrated butadiene-styrene plant. An additional feature is the cheap and plentiful raw material supply.

Commercial Installations: Goodyear Tire & Rubber Co., Beaumont, Texas, (under construction).

References: *Chemical Week*, May 6, 1961, pp. 73-78.



Isoprene — INSTITUT FRANCAIS DU PETROLE

Application: A process for the manufacture of isoprene.

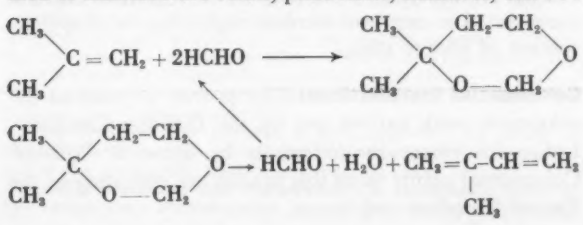
Charge: Isobutylene in a C_4 cut and methanol. (If manufacturer has commercial formaldehyde available, the unit to convert methanol to formaldehyde is unnecessary.)

Product: High purity polymerization grade isoprene monomer.

Description: A two-step process according to:

Methanol is converted into formaldehyde to which recycled formaldehyde is added. The C_4 cut is brought into contact with the formaldehyde solution containing catalyst. The reactor is so designed as to permit various conversions of isobutylene in accordance with the compositions of the varying C_4 cuts used. The dimethylmetadioxane (DMD) is separated and subsequently cracked in a moving bed reactor. The effluent is fractionated and unreacted DMD recycled. Some high grade isobutylene produced by a side reaction is also recycled.

The crude isoprene is distilled to give a very high purity material suitable for any orientated polymerization. Some valuable by-products are obtained which can be used to manufacture resins, plasticizers, additives, etc. . . .



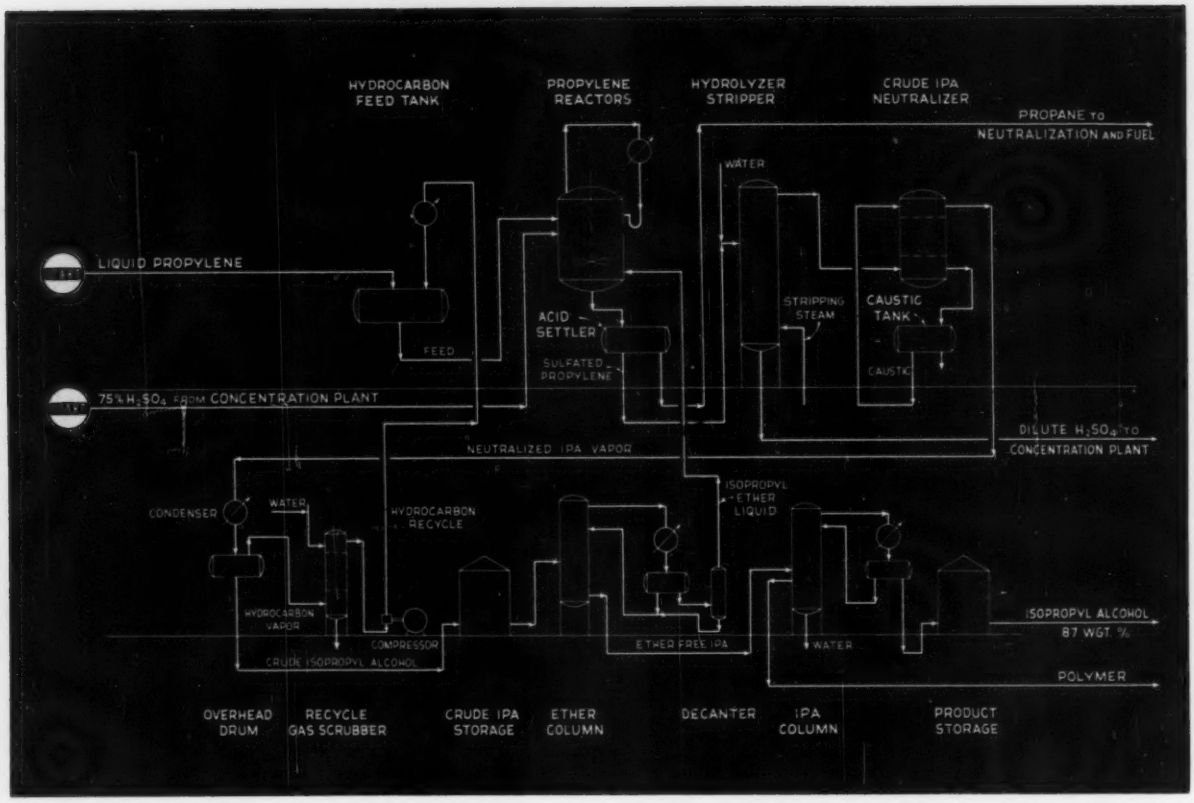
Operating Conditions: The first step reaction (Prins condensation) is complete at 250° F. The catalyst is selective and isobutylene reacts much more rapidly than other olefins. The extraction rate of isobutylene depends essentially on the respective amounts of olefins in the feed and on the desired purity of isoprene (for cuts containing 15 to 18 percent of isobutylene and 35 to 40 percent of 1 and 2 butylenes, the extraction can be as high as 90 percent).

Although the decomposition of DMD is endothermic (120 Btu/mole), it occurs under mild conditions if a suitable catalyst is used. The selected catalyst is cheap and attrition resistant and no regeneration is necessary.

Yields: Including the manufacture of formaldehyde from methanol, one pound of isoprene requires about 1.00 pound of isobutylene and 0.862 pound of methanol; 0.027 pound of MBA and 0.258 pound of by-products are recovered.

An 88 million pounds unit, D.&E. Gulf Coast, would cost about $10 million including formaldehyde production unit, all storage and complete off sites (but excluding power and steam generation).

Reference: Fifth World Petroleum Congress Section IV. Dr. Giraud's conference at Cleveland (AIChE June, 1961 meeting).



Isopropyl Alcohol— STONE & WEBSTER ENGINEERING CORPORATION

Application: A process for manufacturing isopropyl alcohol.

Charge: Liquid propylene. A feed of 65 percent purity or better is desirable to achieve a high alcohol yield, although much lower concentrations of propylene can be handled satisfactorily.

Product: The product is a solution of 87 weight percent isopropyl alcohol. This product can be concentrated to 99 weight percent alcohol by adding one more fractionating step.

Description: The liquid propylene feed stock, combined with recycled hydrocarbons, is first absorbed in 75 percent sulfuric acid in a series of agitated reactors to form a solution of diisopropyl sulfate and isopropyl acid sulfate. The sulfated hydrocarbon solution is converted to an acid solution of isopropyl alcohol, ether and polymer by hydrolysis reactions which take place in the hydrolyzer-stripper in the presence of dilution water. These reaction products are steam stripped from the acid in the same column and leave as overhead vapors. The vapors are neutralized by contact with caustic solution and then condensed.

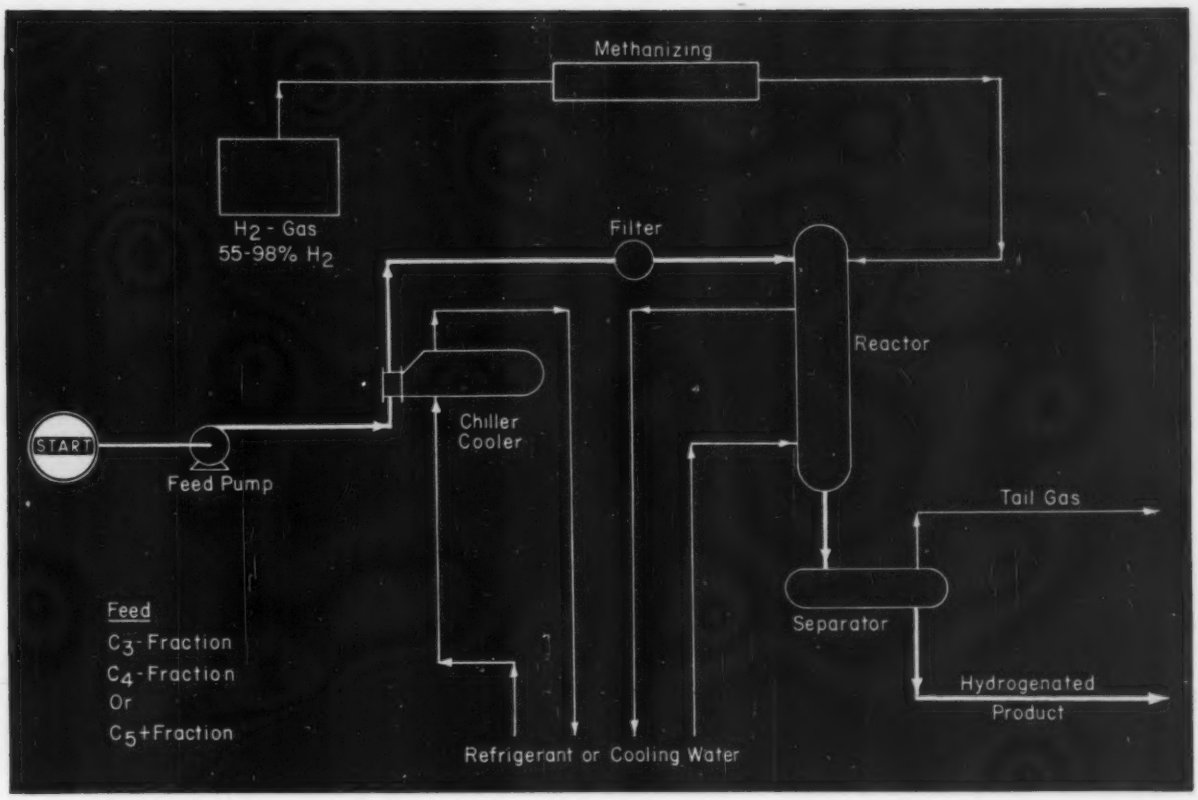
The crude isopropyl alcohol is charged to the ether column. The bulk of overhead vapors from this column is condensed and refluxed to the column. A portion of the liquid is diverted from the main reflux stream and sent to a decanter for separation. In the decanter the two liquid layers are separated; the upper layer is very rich in ether, and the lower layer contains mainly water and small amounts of ether and alcohol. The lower water-rich layer is refluxed back to the tower continuously along with the main reflux stream going to the column. The ether-rich layer is pumped back into the reaction system.

The ether column bottoms are pumped to the isopropyl alcohol column for recovery of the main product. The condensed overhead from this column is the 87 percent solution of isopropyl alcohol in water. Polymer is withdrawn as a side stream from the column and pumped to storage. From the base of the isopropyl alcohol column, water is withdrawn containing only traces of alcohol.

Operating Conditions: The propylene sulfation occurs in the reactors at 300-400 psig. All other equipment, except for the propylene feed tank, operates at near atmospheric pressure. No mechanical refrigeration is required.

Yields: Ninety-three to 95 percent of propylene charged is converted to isopropyl alcohol, depending on propylene content of charge stock.

Commercial Installations: This process is based on development work carried out by the Distillers Company, Ltd., with recent improvements by Stone & Webster. Commercial plants using this process are operating in the United Kingdom and Japan.



Low Temperature Hydrogenation (Bayer Process) — LURGI CORP.

Application: The process is used for the purification of unsaturated hydrocarbons in the liquid phase at about ambient temperature by the hydrogenation of undesirable hydrocarbons with triple bonds such as acetylenes, and/or with several double bonds.

Charge: Hydrocarbon fractions, such as propylene, C_4-fraction and C_5-fraction from pyrolysis, catalytic cracking and dehydrogenation processes.

Products: 1. Propylene containing less than 10 ppm. metylacetylene and less than 20 ppm. propadiene.

2. C_4-Fractions. The residual acetylene content of the selectively hydrogenated product depends on the type and quantity of the acetylenes contained in the feedstock, and on the hydrogenation conditions applied. For example in a C_4-fraction with 30 percent wt. butadiene, vinylacetylene was reduced from 1,300 ppm. to below 50 ppm. and ethylacetylene from 600 ppm. to below 150 ppm.

3. C_4-Fraction with less than 0.2 wt. percent butadiene from C_4-fraction containing 0.5-5 wt. percent butadiene.

4. Pyrolysis Gasoline, free of diolefins, stable to storage, without loss in octane number.

Description: The liquid feedstock containing the undesirable unsaturated hydrocarbon compounds, (acetylenes and diolefins), is cooled to reaction temperature. After water separation in a special filter, feedstock and hydrogen gas are fed to the reactors under controlled conditions. The liquid feed is uniformly distributed by a special device over the tubes filled with catalyst in the presence of the hydrogen gas, and trickles downwards through the catalyst in the hydrogen atmosphere. The heat of reaction is removed indirectly by refrigeration or cooling water. The hydrogenated product leaving the reactors is separated from the tail gas in a separating drum. Flow and temperature controllers permit fully automatic operation of the plant.

For continuous operation, it may be preferable to install two reactors, one thereof as standby.

The flowsheet also includes a methanisation unit which is normally necessary to reduce the CO content of the hydrogen gas to the permissible level of less than 10 ppm.

Operating Conditions and Characteristics of Feedstocks: Selective low temperature hydrogenation generally occurs at temperatures of between 50 and 120° F and pressures of between 30 and 300 psig., in the liquid phase (trickle phase), and in the presence of a special catalyst. The operating pressure for cracker gasoline is about 750 psig. The catalyst has an extremely long service life, without suffering any loss in activity. In an existing commercial plant, the catalyst still showed its original activity after 14 months of continuous operation, without any regeneration. Regeneration of the catalyst can be accomplished outside the reactor by simple burning-off at 750-930° F, should this become necessary. Since the catalyst is highly resistant to abrasion, losses of catalyst are kept at a very low level, and will not exceed 10 percent of the reactor charge per annum.

The hydrocarbon feedstocks should be free of catalyst poisons, such as hydrogen sulfide and chlorine compounds. The hydrogen gas with at least 50 percent vol. hydrogen may contain inert gases and saturated hydrocarbons, but should be free of catalyst poisons. Its carbon monoxide content must be less than 10 ppm. Carbon monoxide removal is generally accomplished by methanisation.

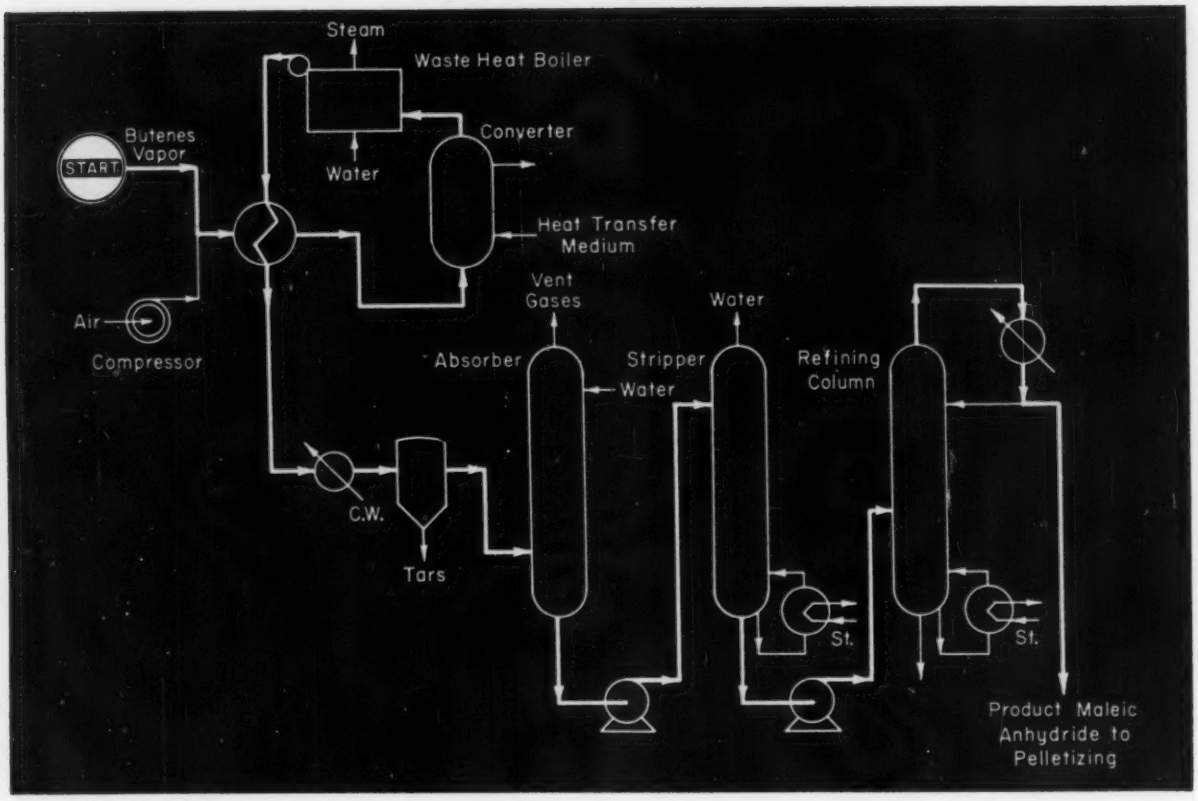
	C_3	C_4 with acetylenes	C_4 with butadiene	Cracker Gasoline
Temperature °F	50-70	50-70	85→140	85→160
Maximum pressure psig.	220	115	220	450
Space velocity W/H/V (lbs. of feed per hour per cubic foot of catalyst)	1,250	1,250	620	375
Reaction heat—btu's per pound of feed	37	27	20	145
Consumption of 100% hydrogen in SCF per pound of feed	0.32	0.2	0.2	0.95

Yield: Propylene: more than 99.5 percent wt. of the propylene input.

C_4-Fraction: The yield of butadiene depends on the amount of acetylenes and is about 98 percent wt.

Cracker Gasoline: 100 percent

Commercial Installations: Propylene fractions hydrogenation and C_4 fractions hydrogenation by Erdolchemie, Dormagen (Germany). Under construction: C_4 fraction hydrogenation, Erdolchemie, Dormagen and C_4 fraction hydrogenation, Esso, Cologne.



Maleic Anhydride (Butenes)

Application: A process for manufacturing maleic anhydride by the catalytic oxidation of butenes.

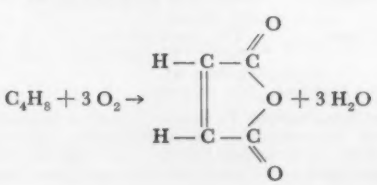
Charge: A C_4 hydrocarbon stream containing 80+ percent n-butenes.

Product: Solid maleic anhydride (as pellets, flakes, or briquettes), 99.5 percent minimum assay.

Description: Normal butenes, derived from butane dehydrogenation or alternate sources, are mixed with a large excess of air at 15-25 psig. Although the theoretical ratio is much lower, a volume ratio of about 75/1 air/butenes is used in order to avoid explosive compositions. The mixture is preheated by exchange with hot reactants and then fed to the converter.

The converter consists of a vertical shell-and-tube unit with catalyst pellets packed in the tubes and a high-temperature heat transfer medium such as fused salt in the shell. The catalyst is, typically, vanadium pentoxide/phosphorous pentoxide on an alumina support.

Maleic anhydride is formed at 800-900° F and 10-15 psig by the following reaction:



Butanes and a portion of the butenes are also oxidized directly to carbon dioxide and water. About 0.85 pounds of maleic anhydride are formed per pound of contained butenes. Conversion of hydrocarbons is essentially complete. The reaction is of the "hot spot" type, with most of the conversion taking place over a limited zone in the converter. The very large exothermic heat of reaction is removed both by the heat transfer medium and by the large excess of air in the feed.

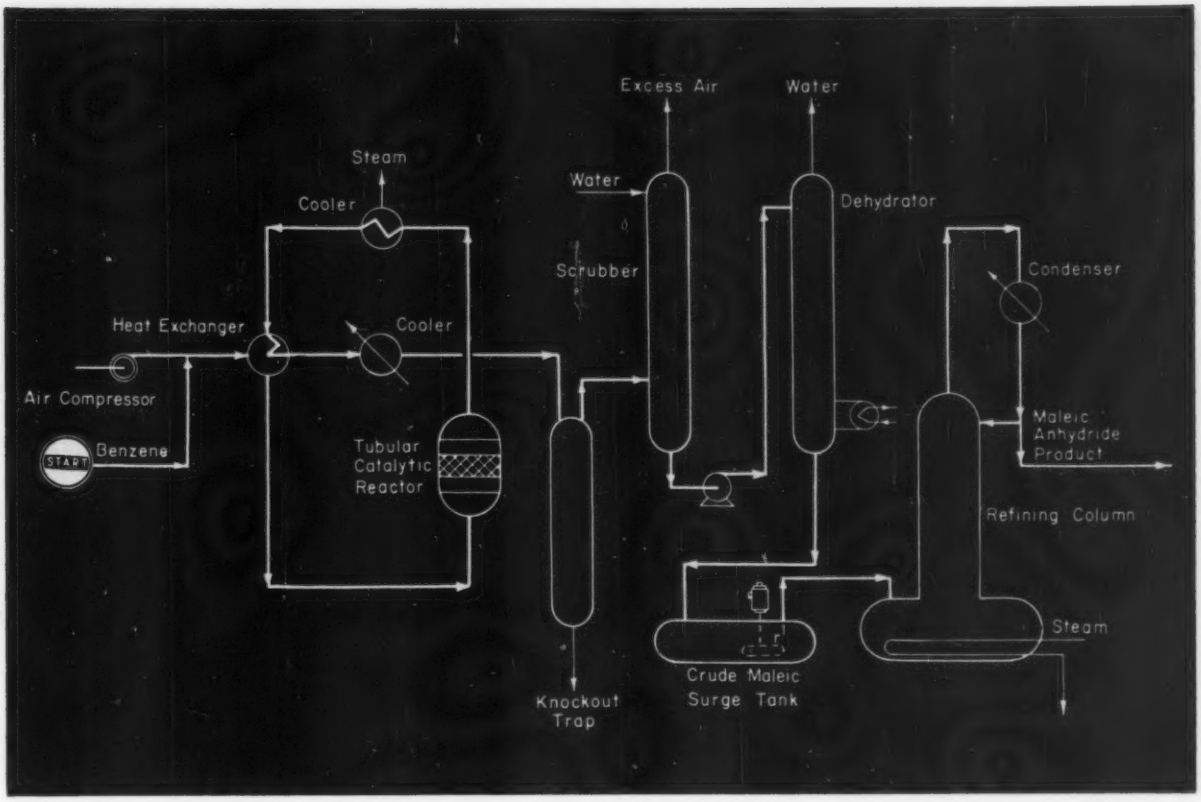
The reaction products comprise maleic anhydride, water vapor, fixed gases, and minor amounts of oxygenated byproducts. The effluent stream is cooled in a series of exchangers and passed through a tar separator to the absorber. Here maleic acid is removed by water scrubbing.

The maleic acid bottoms from the absorber are pumped to a water stripper (a portion may be diverted to fumaric acid manufacture) where the anhydride is obtained. This material is then given a final fractionation and sent to pelletizers where the final solid product is obtained.

Operating Conditions: Given in the above text.

Yields: Over-all process yield is about 50 percent of theory.

Commercial Installations: This process or a variation is being installed by the Petro-Tex Chemical Corp. at Houston, Texas.



Maleic Anhydride—SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of maleic anhydride.

Charge: Benzene, nitration grade.

Product: Maleic anhydride, pellets.

Description: Benzene is vaporized and mixed with air. The mixed gases are preheated and passed to a multitubular, cooled catalytic reactor.

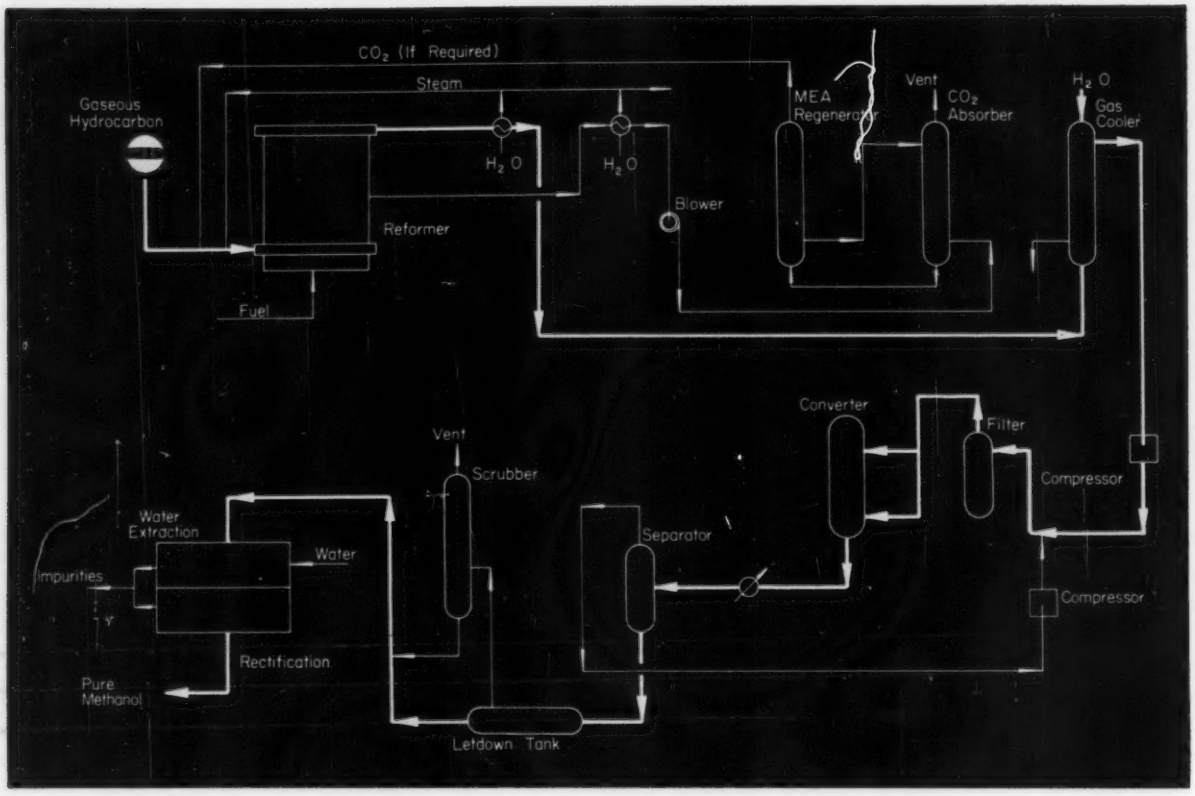
The reactor effluent gases pass through three coolers in sequence. The first cooler generates steam. The second is a recuperative exchanger which serves to preheat feed gas. The third cooler uses cooling water. Tarry condensates are removed by a knockout trap. The reactor effluent gases then pass to a water scrubber where maleic anhydride is absorbed. The maleic acid solution is pumped to a dehydrator which regenerates maleic anhydride. Only a minimum of maleic is transformed to isomeric fumaric acid in the dehydration step, by careful control of conditions. The crude maleic anhydride is purified in a refining column. The product cut is pelletized and bagged in conventional machines.

Tempered cooling water is used to prevent plugging of the reactor aftercooler by solid maleic anhydride. A startup heater (not shown on this schematic flow diagram) serves to bring the feed airstream up to reaction temperature. This preheater burns natural gas or other cheap fuel.

Operating Conditions: The most important operating variables are the benzene concentration in the reactor inlet gases, the temperature in the reactor, and the contact time. A careful analysis of all these parameters, combined with a uniquely efficient SD-developed catalyst, has permitted SD's maleic anhydride process to achieve hitherto unattained commercial yields.

Commercial Installations: Compagnie Francaise des Matieres Colorantes, Villers-St. Paul, France; American Cyanamid Co., Bridgeville, Pa.; Ftalital, S.p.A., Bergamo, Italy; Monsanto Chemicals Ltd., Newport, England; Monsanto Chemical Co., St. Louis, Mo.; Pittsburgh Chemical Co., Pittsburgh, Pa.; Monsanto Canada Ltd., La Salle, Canada; Heyden-Newport Chemical Corp., Fords, N.J.; Miike Gosei Chemical Industry Co. Ltd., Omuta City, Japan; S. A. Reichhold-Beckacite, Niort, France; Societe Chimique de Selzaete, Selzaete, Belgium; Rheinpreussen A.G., Meerbeck, Germany; Ewald-Kohle A.G., Recklinghausen, Germany; and Bombrini Parodi-Delfino, S.p.A. A reaction system using the SD catalyst has been in commercial operation at Reichhold Chemicals' Elizabeth, N.J., plant for several years.

Reference: *Chemical Engineering,* July '53, p. 238; *Petroleum Processing,* November (1956), p. 82-89.



Methanol — CHEMICAL CONSTRUCTION CORPORATION

Application: This is a process for the manufacture of methanol.

Charge: The feed to the process may be any mixture of gaseous hydrocarbons below hexane consisting primarily of saturates, or acetylene off-gas, or a mixture of hydrocarbons and off-gas.

Description: Hydrocarbons are reformed to hydrogen, carbon monoxide and carbon dioxide by reaction with steam at about 30 psig.

Methanol requires slightly different reformer operating conditions than those for the production of ammonia synthesis gas. A somewhat lower reformer pressure is used and there is no secondary reforming step. No carbon monoxide shift converter is required for methanol production.

Some feed gases require that carbon dioxide be added to the gas stream before reforming. In this case the required quantity of carbon dioxide is recovered from the flue gas from the reforming furnace by scrubbing with MEA solution, if carbon dioxide is not available from another source.

The reformed gas is cooled in a waste heat boiler and then by direct contact with water. It is then compressed to 5,200 psig at which pressure it is synthesized to methanol as illustrated.

The methanol is almost completely condensed in a water cooled exchanger and then passes into the separator. Gases dissolved in the raw product methanol at 5,000 psig flash from the liquid when the pressure is reduced in the let-down tank. Methanol in the flash gas is recovered and mixed with raw product.

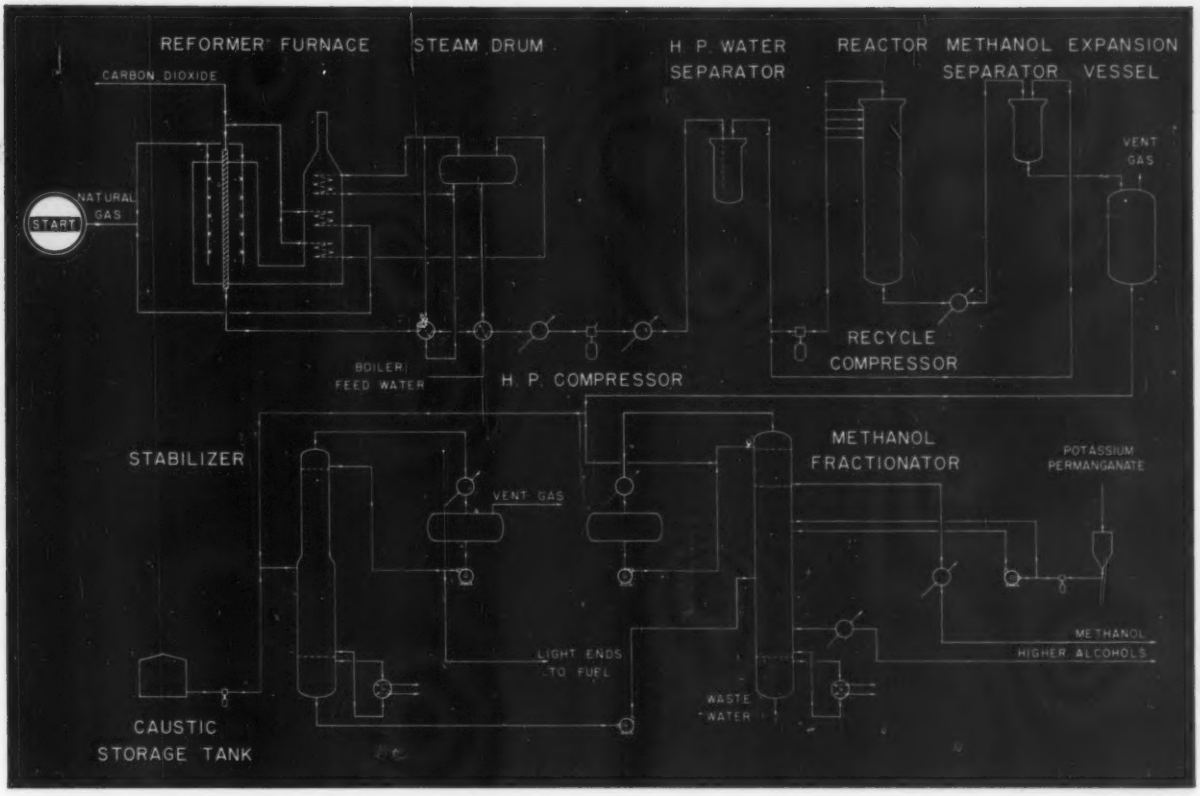
A product consistently high in purity is produced in the purification section due to a unique new design in the method of concentration and removal of impurities from the methanol stream.

Utilities and capital investment costs have been substantially reduced by this new design.

Products: The refined product methanol has a purity of 99.85 percent.

Operating Conditions: Important operating conditions are given in the preceding description.

Commercial Installations: There are a number of domestic and foreign installations in operation or under construction.



Methanol (Uhde)—ARTHUR G. McKEE AND COMPANY

Application: A process for manufacturing synthetic methanol.

Charge: Natural gas, ethane, LPG, any light hydrocarbon.

Product: Pure anhydrous methanol.

Description: Methanol is produced by the reaction of carbon monoxide or carbon dioxide with hydrogen. The process is catalytic and carried out at elevated temperature and pressures. Any suitable source of H_2 and CO or CO_2 may be used to produce the synthesis gas. Under U.S. economic conditions the most favorable source is high-pressure reforming of natural gas with steam.

Steam-methane reforming produces a gas in which the ratio H_2/CO is higher than desirable for the methanol reaction. This ratio is theoretically 2.0, but a ratio of 2.25 is normal practice. To achieve the desired balance, carbon dioxide from any available outside source may be added in the H_2/CO_2 ratio of 3.25 to react with excess H_2.

In steam-methane reforming the natural gas at approximately 150° F is preheated to 850° F and mixed with steam likewise preheated to 950°-1000° F. Carbon dioxide required to achieve the desired $H_2/CO + CO_2$ ratio is added, and the mixture passes to a bank of catalyst tubes in the radiant section of a furnace. High temperatures favor the reforming reaction. Excess steam is used to insure complete utilization of the methane.

Leaving the catalyst tubes the mixture is quenched with water to bring its temperature below reaction temperature as quickly as possible. It then exchanges heat with boiler feed water and is cooled with water before going to the high pressure compressor. This compressor raises the pressure of the mixture to that of the reactor system, 4,600 psig.

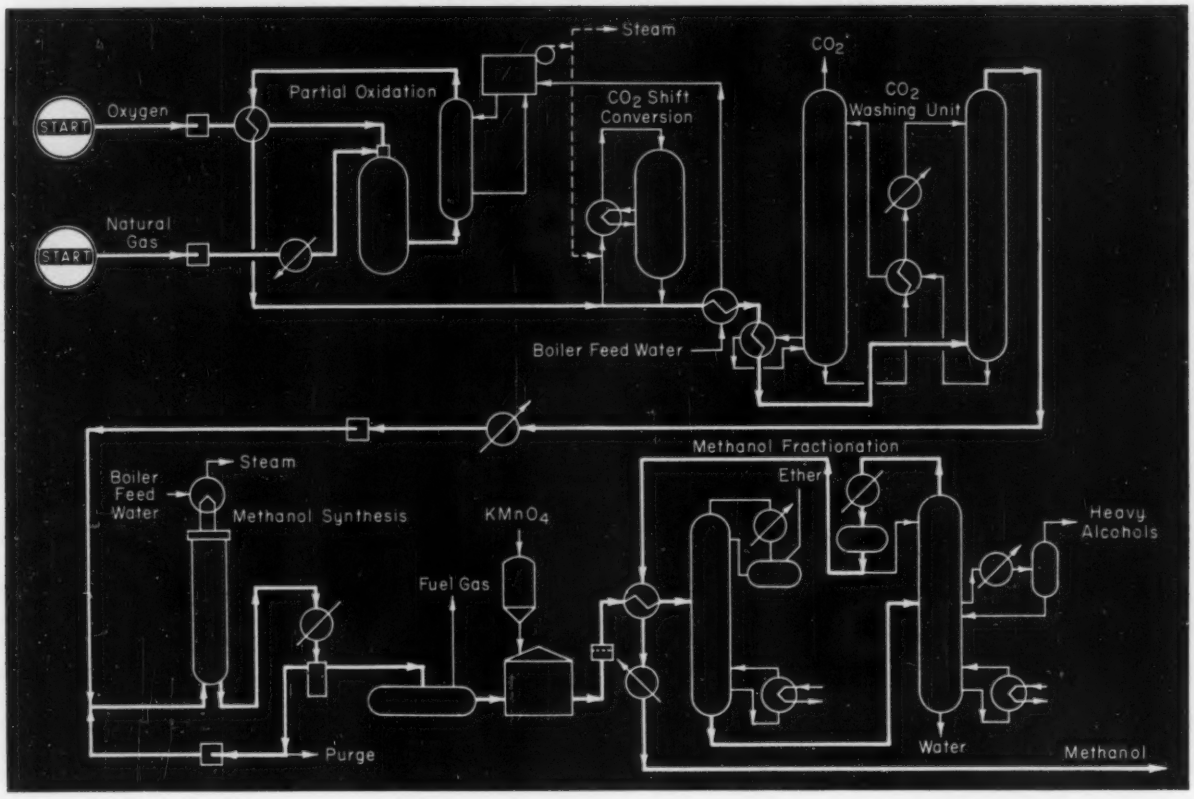
The Uhde methanol reactor consists of catalyst beds mounted in a high-pressure container. The main body of reacting gas enters at the top of the vessel and passes down along the shell through an annular space. This preheats the gas and keeps the pressure shell cool. The pressure shell is therefore constructed of heat-treated steel. A stainless steel or copper lining is used because of corrosion possible from the high partial pressure of CO. At the bottom the gas passes through the shell side of a shell-and-tube-type exchanger built within the pressure shell. Here it is heated by the reaction products leaving the convertor. Leaving the heat exchanger the feed gases pass through a central tube to the top of the reactor and then down through the first bed of catalyst.

The reaction of H_2 and CO is strongly exothermic. To regulate the temperature over the catalyst some of the feed gas by-passes the preheater. It enters directly into the space between the catalyst beds cooling the gases leaving the catalyst bed above.

The gases leaving the bottom catalyst bed pass through the tube side of the internal heat exchanger before leaving the reactor. They are then cooled with water and pass to the methanol separator where the condensed methanol is withdrawn. The unreacted gases are returned to the reactor by the recycle compressor. The methanol is depressured to an expansion vessel in which the dissolved gases are flashed and vented. It is then stabilized to remove light ends (ethers, hydrocarbons and noncondensibles). A small amount of caustic solution is added with the stabilizer feed to neutralize the acids formed as by-products.

The stabilized methanol is charged to the methanol fractionator for purification. A recycled sidestream withdrawn from the fractionator is treated with 1 percent potassium permanganate solution to remove aldehydes, etc., by oxidation. The overhead product of this fractionator is returned to the stabilizer where it joins the light ends stream. The purified methanol is withdrawn as a sidestream. Higher alcohols are withdrawn farther down the fractionator. The salts, MnO_2 and water are withdrawn to waste at the bottom of the tower.

Operating Conditions: The methanol synthesis is carried out at 4,600 psig. In the catalyst beds the reacting gases enter at approximately 615° F.



Methanol—MONTECATINI

Application: A process for the manufacture of rectified methanol based on catalytic synthesis from a gaseous mixture of carbon oxides and hydrogen.

Charge: Any mixture of gaseous hydrocarbons, or aceytlene off-gas; oxygen 98 percent pure.

Product: Methanol, 99.9 percent pure.

Description: The gaseous charge is first compressed at 450 psig, preheated and partially oxidized into a furnace operating at about 2300 °F. in order to obtain a low content in residual methane. For oxidization purposes highly pure oxygen (not less than 98 percent) is used, to limit the content in the final synthesis gas of inert components.

The gas leaving the furnace flows through a waste heat boiler in which saturated steam at 550 psig is produced in an amount exceeding the total requirements of the whole process.

The flow gas is essentially formed by a mixture of carbon monoxide and hydrogen, containing minor amounts of carbon dioxide, methane, nitrogen and water. The hydrogen to carbon oxides ratio in the oxidized gas is slightly lower than the stoichiometric value which can be foreseen from the reaction equations:

$$CO + 2H_2 \rightarrow CH_3OH$$

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$$

It is therefore necessary to remove a small amount of carbon oxides to obtain a slight excess of hydrogen which fosters the kinetic of the above mentioned reactions.

This is accomplished as follows: a small fraction of oxidized gas (20 to 25 percent when starting from natural gas) is sent to a shift converter in which carbon monoxide is converted to carbon dioxide, yielding hydrogen from steam.

The converted gas, mixed with the unconverted gas fraction flowing from the boiler, yields heat which can be used, for instance, for stripping the carbon dioxide absorbing solution; the gas mixture is then sent to a washing tower in which the carbon dioxide content is lowered down to 1-2 percent.

The washed gas is now compressed to about 4,200 psig, mixed with the recycle gas and finally enters the converter. The latter is identical in design to the well known Montecatini-Fauser ammonia converter.

This method gives strict temperature control and thus allows a good conversion and a high degree of purity in the obtained product. Water, circulated in the cooling elements placed inside the converter, is cooled in a waste heat boiler yielding steam at 100 psig.

The effluent gas from the converter is cooled in a condenser; here crude methanol is separated as a liquid phase and the unreacted gas is recycled by a compressor.

Crude methanol is pumped from the separator vessel to a let down tank, operating at about 200 psig, in which the dissolved gases are given off. From the let down tank the crude product is fed to the purification unit. Purification is carried out in three steps: first a diluted potassium permanganate solution is added to the crude methanol to oxidize the aldehydes, ketones and other impurities contained therein in small amounts. Secondly, the alcohol is pre-heated and fed to a distillation column in which light ends (essentially dimethylether) are removed. In a third step the bottoms of first column are fed to a second tower which separates pure methanol produced as top effluent, from water which is withdrawn as bottom effluent; higher alcohols are removed as a sidestream from the lower part of the fractionation tower.

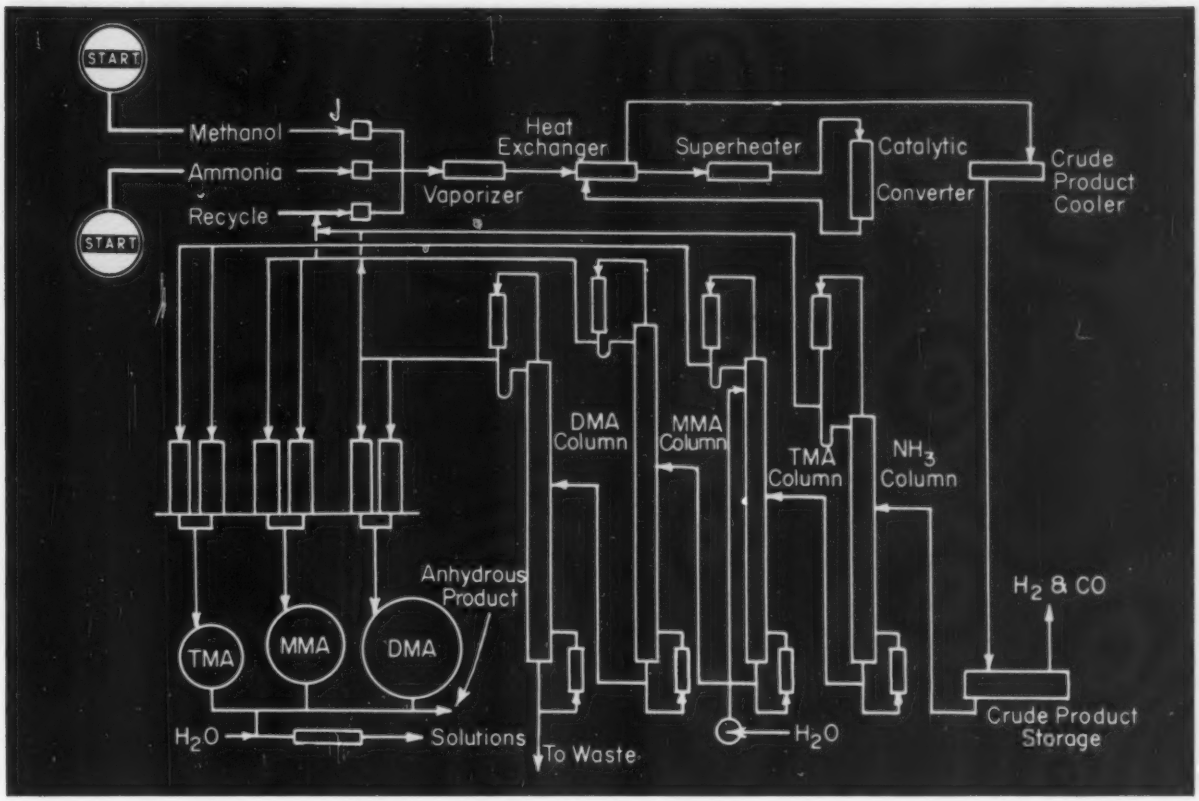
Operating conditions: The working pressures in the various stages of the cycle have been already indicated in the above description.

Temperatures are, approximately, as follows: in partial combustion furnace: 2300 °F.; in shift conversion of carbon monoxide and steam to CO_2 and H_2: 750 °F.; in methanol synthesis reactor: 740 °F.

Yields: For the production of 100 kg of rectified methanol 920 N cubic meters of 100 percent methane and 620 N cubic meters of 100 percent oxygen are required.

Commercial installations: Montecatini has built a total of 10 plants for methanol production in five different countries.

One unit, having a capacity of 150 metric tons per day from acetylene off-gas is under construction at Brindisi-Italy.



Methylamines— THE LEONARD PROCESS COMPANY

Application: A continuous process for the manufacture of mono, di, and tri-methylamines, CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$.

Charge: Technical grade anhydrous ammonia, and synthetic methanol.

Products: Anhydrous or aqueous solutions of mono, di, and trimethylamine.

Description: Anhydrous ammonia, synthetic methanol, and recycle liquid are fed continuously at controlled rates to a vaporizer which converts the liquid to a gas stream which then flows successively through a heat exchanger and superheater and into a converter packed with an amination catalyst where the ammonia and methanol react to form the amines. The reaction is exothermic and part of this heat of reaction is recovered by passing the hot exit gases from the converter through the heat exchanger to heat up the forward gas flow. The gas stream from the heat exchanger passes into a condenser which liquefies the stream and permits storage of the crude product until it is distilled.

From the crude product storage, the mixture of NH_3, Mono, Di, and Tri-methylamines and water are fed to four distillation columns in series. The first column separates out the excess ammonia and part of the trimethylamine which forms an azeotrope with ammonia as an overhead stream which is recycled. The bottoms are fed to the second column into which water is fed near the top to perform an extractive distillation which permits pure trimethylamine to be withdrawn overhead and taken to product storage, or recycle as desired. The bottoms are fed to the third column where pure monomethylamine is taken off as a top product stream which can be piped to storage, or recycled as desired. The bottoms are fed to the fourth column where pure dimethylamine is taken off as an overhead product while the water is drained to waste from the column bottom.

Since the reaction system is a perfect equilibrium system, any amount of the tri, mono, or dimethylamine can be taken off as product from the system, and any amount not wanted as product can be recycled, and the recycled material suppresses the formation of an equivalent amount of that material. This permits great flexibility in the operation of the plant and gives the ability of meeting peak demands for sale of various products. All three products are better than 99 percent pure.

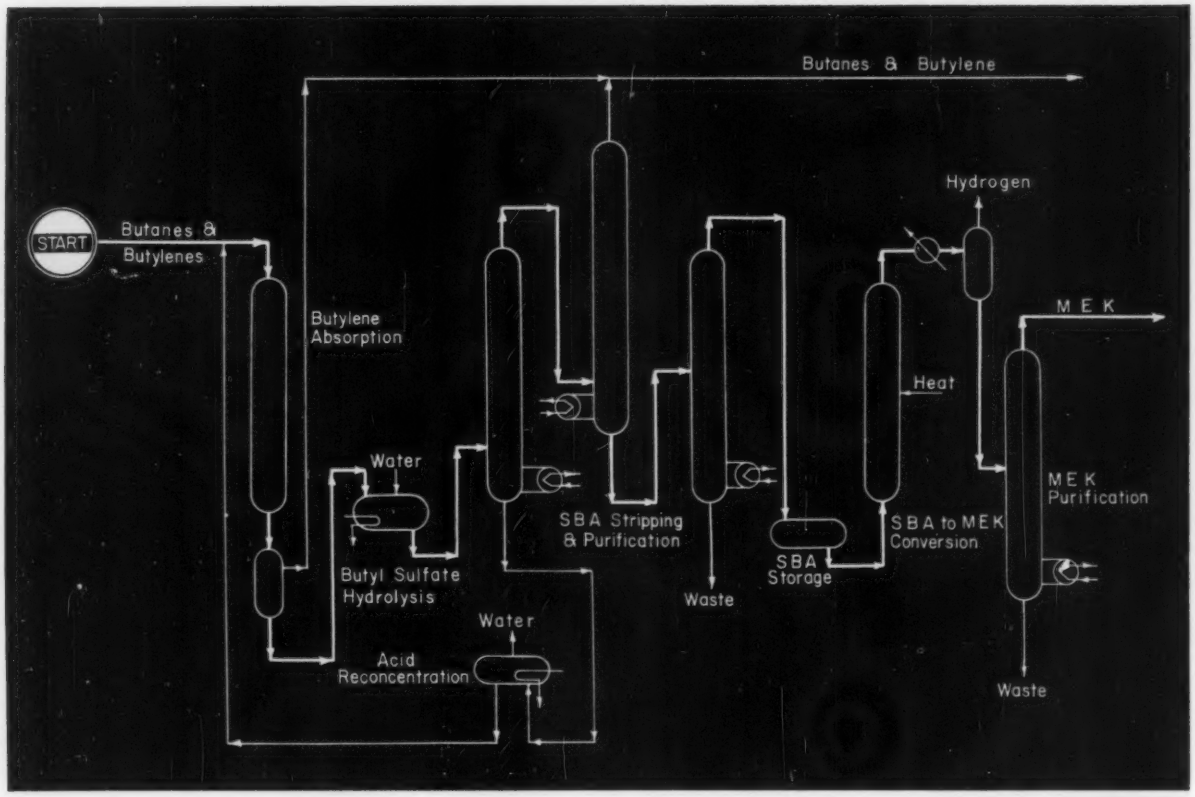
The entire operation is continuous and is instrumented so that one operator per shift controls the plant.

All process equipment and piping is fabricated of carbon steel which, since the methylamines are excellent corrosion inhibitors, lasts indefinitely.

Yields: Over-all yield of both ammonia and methanol is above 95 percent.

Commercial Installations: The Leonard Process Company, 437 Fifth Avenue, New York has two plants in operation in the U. S. (Commercial Solvents Corp. and Pennsalt Chemicals Corp.) and a new major plant under design for Escambia Chemical Corporation in the Far East, Nitto Chemical; in Italy, Persae Chemical; in Belgium, Union Chimique Belge's combination Methylamines-Dimethylformamide plant, under construction; in England, Imperial Chemical Industries, under construction.

Reference: PETROLEUM REFINER, Vol. 37 No. 9 Sept. 1958 pp. 373.



MEK & sec-Butyl Alcohol (Maruzen)—SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of *sec*-butyl alcohol (SBA) and/or methyl ethyl ketone (MEK).

Charge: Butylenes.

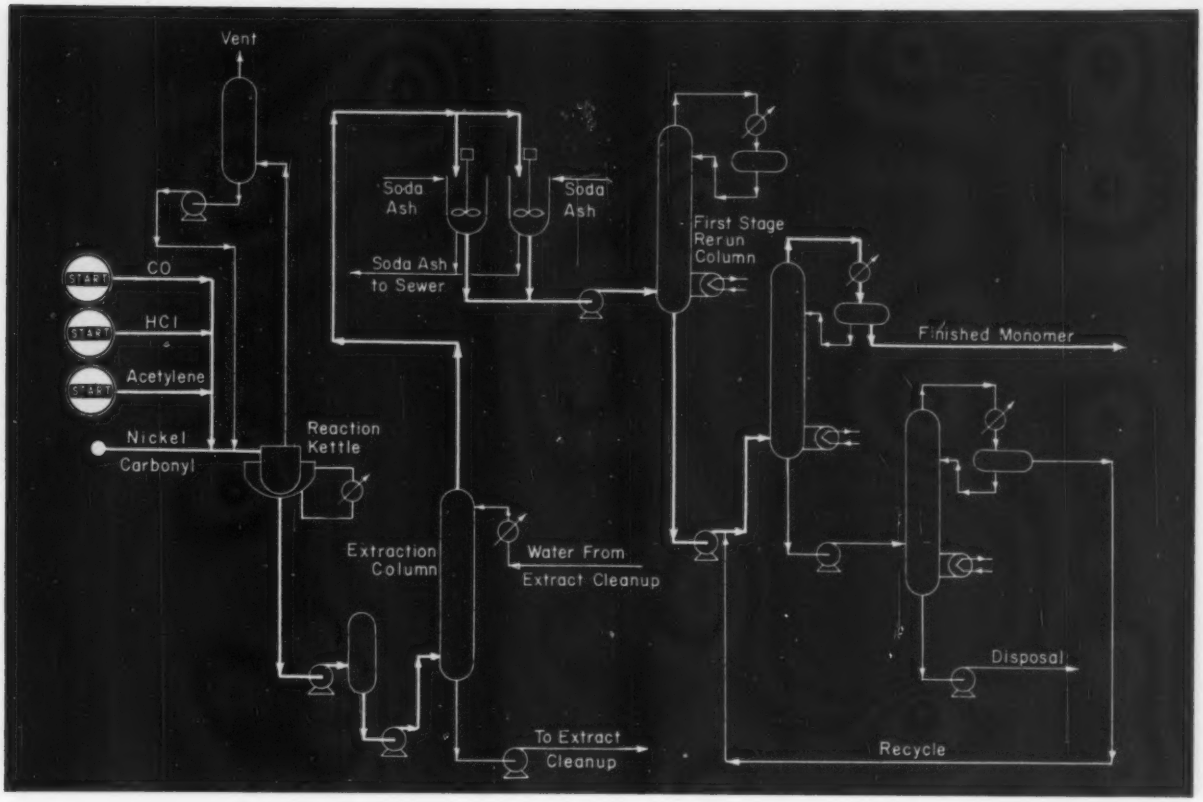
Products: *Sec*-butyl alcohol and methyl ethyl ketone, liquids.

Description: The Maruzen process uses a mixed hydrocarbon feed stream of butanes and butylenes. The first step is absorption of *n*-butene in sulfuric acid to form butyl sulfate and dibutyl sulfate esters. Careful control of acid concentration and temperatures is necessary in the absorption of butylene to prevent formation of polymers. If isobutylene is present in the process feed, a preliminary selective absorption with sulfuric acid is provided to remove this component. The butyl sulfate and dibutyl sulfate esters are hydrolyzed to *sec*-butyl alcohol and sulfuric acid by the addition of water to the combined acid-hydrocarbon-water system. Careful control of agitation and temperatures is necessary to promote maximum yield and to minimize polymer formation.

The hydrolyzed mixture of *sec*-butyl alcohol and sulfuric acid is charged to a stripping column where crude SBA is removed overhead along with any butylenes formed in the stripper. A series of distillation steps separates water and other impurities, producing SBA of high purity. Sulfuric acid, diluted with water during stripping, is conserved for re-use in the absorption system by reconcentration and purification prior to recycling. The hydrogenation of SBA to MEK is effected by passing the SBA through heated tubes packed with catalyst. Hydrogen separated from the crude MEK is stripped of retained heavy vapors and is available as a pure byproduct. Crude MEK is distilled to meet desired commercial specifications.

Economics: The Maruzen process is competitive with any other in the world. Capital costs of an SBA-MEK installation based on this process will be influenced by feedstock composition, plant size, and location. Operating costs, too, depend to a large extent on local raw materials and to a lesser extent on labor and utility costs.

Commercial Installations: Maruzen Oil Co., Ltd. (Maruzen Petrochemical Co., Ltd.), Shimotsu, Japan.



Methyl & Ethyl Acrylate Monomer — ROHM & HAAS COMPANY

Application: This process is used for the manufacture of either methyl or ethyl acrylate monomer.

Charge: The materials used for this process consist of nickel carbonyl, carbon monoxide, acetylene, methyl or ethyl alcohol and hydrogen chloride.

Products: The products are methyl or ethyl acrylate, to which a polymerization inhibitor, such as the methyl ether of hydroquinone, is added before storing and shipping.

Description: In the unique process described here, five starting materials are brought together in carefully controlled ratios in a continuous process. The reaction to produce the acrylates is carried out in an agitated stainless steel reaction kettle provided with cooling. The reactants are introduced into the vessel under the surface. Preferred conditions include a temperature of 30 to 50° C; $HCl\text{-}Ni(CO)_4$ equivalent ratio of 1:1.01 to 1:1.2; acetylene-total CO ratio of 1.01:1 to 1.1:1; and an alcohol-total CO ratio of 1.1:1 to 3:1 (alcohol also acts as a solvent to improve fluidity). With five raw materials to be introduced at essentially the same time in correct ratios, instruments for accurately controlling starting material feed rates are an important factor.

Before venting, inert gases, impurities in the feeds, and traces of alcohol, nickel carbonyl, and acrylate are scrubbed with alcohol in order to recover usable materials and to remove all traces of carbonyl. The liquid stream from the reactor is stored under refrigeration to prevent polymerization and then is fed continuously to a packed extraction column. Recycled chloride brine enters the top of the column, extracts the alcohol, salts out the acrylate, and is withdrawn from the bottom of the column. The crude acrylate comes off the top. Material from the bottom of the column goes into a series of distillation columns to separate alcohol and brine and to concentrate the alcohol. The alcohol comes off the top of the final column and is recycled to the process. The brine coming from the bottom of this final column is recycled to the wash column with the excess being returned to the nickel carbonyl unit. Process inhibitors are added at the top of the columns to prevent polymerization.

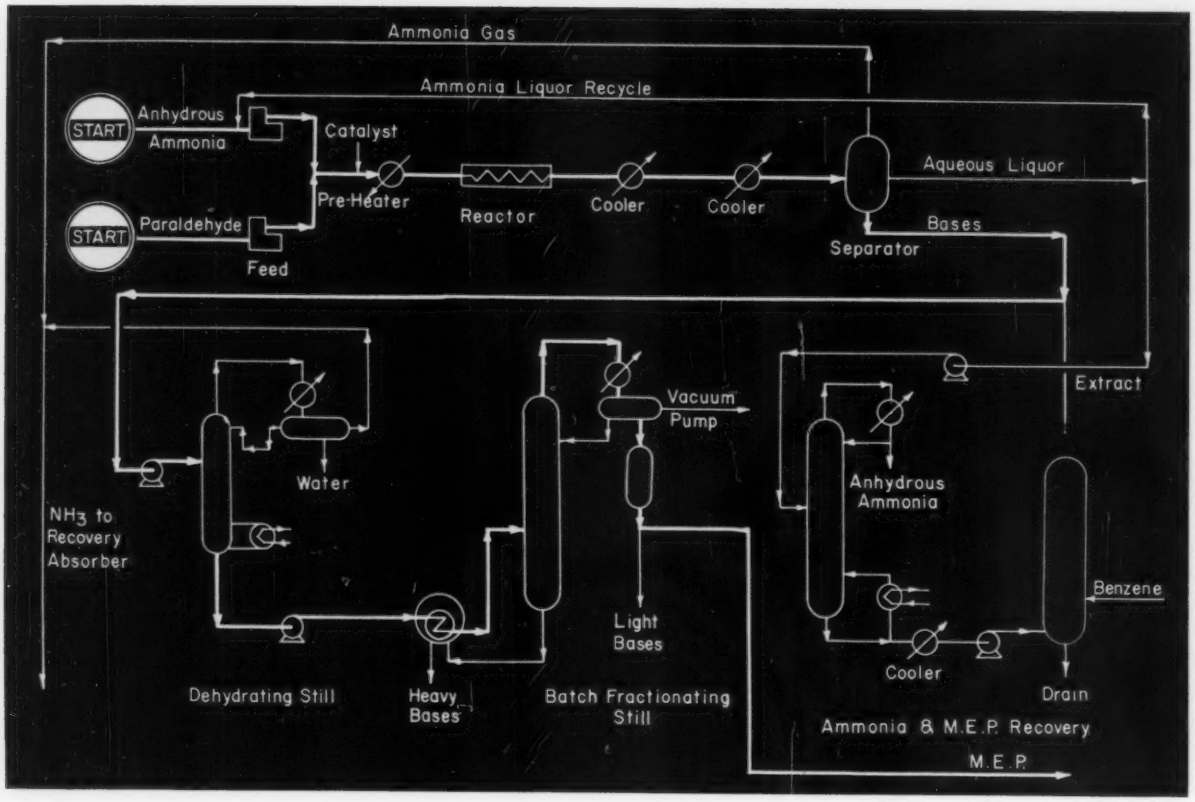
The main stream containing the acrylate is washed batchwise with a soda ash solution to neutralize small amounts of hydrochloric and acrylic acid. The neutralized acrylate solution is fed continuously to a series of columns to produce the final product. In the first column small amounts of water, light hydrocarbons, etc., are removed overhead. In the second column the finished product is removed overhead and the heavy ends, together with some acrylate, leave at the bottom. Process inhibitors are again added to prevent polymerization. Columns are operated under vacuum and acrylate monomer is condensed by means of refrigerated water. The finished monomer, after being mixed with its shipping inhibitor, is stored in large tanks.

Bottoms from the second stage column are pumped to a third stage column which is also operated under vacuum. The overhead from this column contains mainly acrylate and is recycled to the first stage column while the residue, containing polymers, tars, etc., is sent to the decontamination furnace and burned.

Operating Conditions: The principal operating conditions have been mentioned in the description above.

Commercial Installations: Two units for the production of methyl and ethyl acrylate have been constructed by the Rohm & Haas Company in Houston.

Reference: *Ind Eng. Chem.*, **51**, 1232, 1328 (1959).



Methyl Ethyl Pyridine — PETROCARBON DEVELOPMENTS LIMITED

Application: A process for the manufacture of methyl ethyl pyridine.

Charge: Technical grade paraldehyde and 35-45 percent aqueous ammonia.

Product: 2, methyl-5, ethyl pyridine.

Description: The basic reaction is:

$$4\,(CH_3CHO)_3 + 3\,NH_3 = 3\,C_2H_5 - \underset{N}{\overset{}{\text{C}_5\text{H}_3\text{N}}} - CH_3 + 12\,H_2O$$

The reactants are fed continuously by metering pumps, together with a small amount of liquid catalyst, into a system of one or more preheaters, followed by a reactor. The reactor is stainless alloy tube jacketed with a heat transfer oil. A reaction temperature of 200-240° C. is maintained by heating the oil and a pressure of 1,500-2,000 psi is maintained by a pressure control valve on the reactor outlet. High yields are dependent on close temperature control and large excess of ammonia as well as paraldehyde purity.

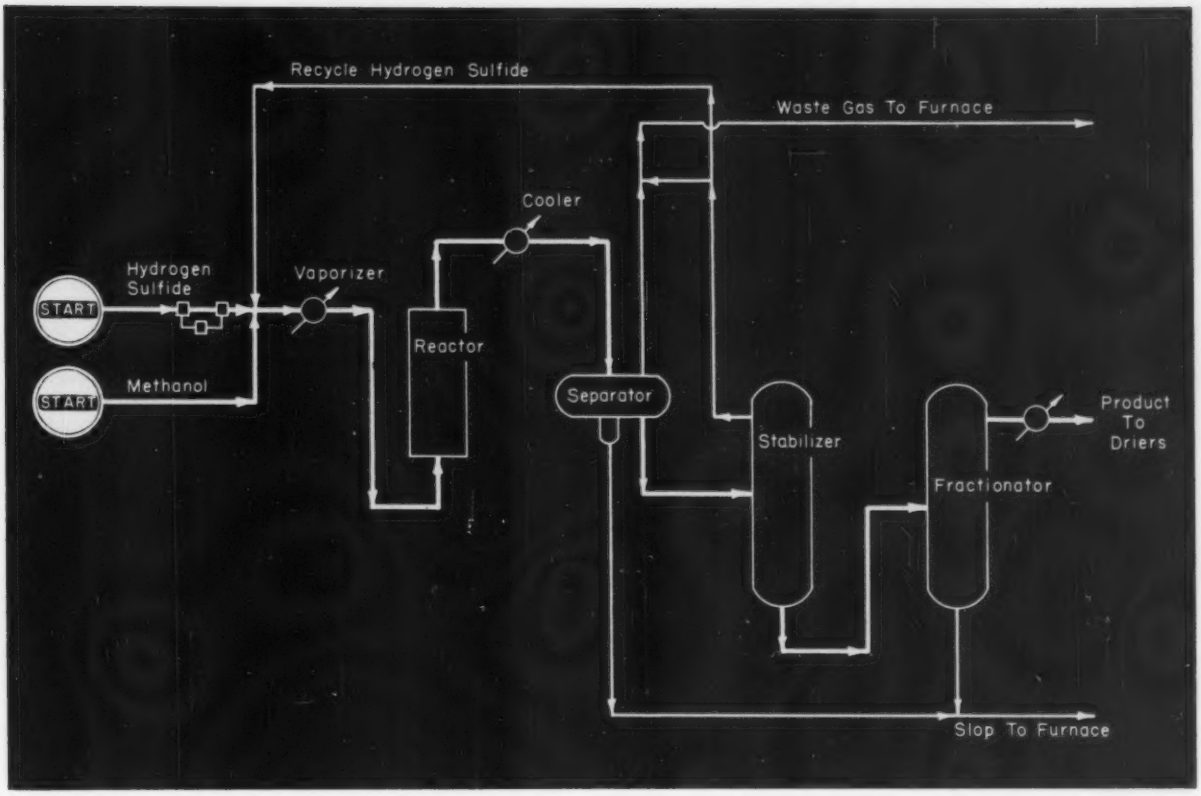
The reaction mixture passes through an exchanger, a control valve and a second cooler to a separator where the ammonia flashes off to a recovery absorber. Two layers are formed, a heavy layer comprising substantially pyridine bases and a lighter aqueous layer.

The bulk of the aqueous layer is recycled to reactor feed, the remainder being stripped of ammonia in a conventional ammonia still. Stripped aqueous liquor from the ammonia still is finally scrubbed with benzene to recover dissolved M.E.P. and other bases.

A preliminary azeotropic distillation is necessary in order to remove dissolved water and ammonia from the crude bases layer, and the benzene extract from the recovery scrubber may be conveniently used here. The dried bases are fractionally distilled in a batch still, employing a good vacuum. With an efficient 25 plate column and a high reflux ratio, an M.E.P. fraction of at least 98 percent purity is obtained, boiling entirely between 175-180° C. at atmospheric pressure. The yield is 68-72 percent on the paraldehyde input. Some recycle of intermediate cuts is necessary in order to achieve maximum recovery of specification M.E.P.

Distillation fore-runnings contain small amounts of alpha-picoline, and unreacted paraldehyde. The still residue contains heavy pyridine bases.

Yields: A yield of 68-72 percent based on paraldehyde feed.



Methyl Mercaptan— AMOCO CHEMICALS CORPORATION

Application: A process for the manufacture of methyl mercaptan.

Charge: Raw materials to this process are methyl alcohol and hydrogen sulfide.

Product: Methyl Mercaptan (98 mole percent pure).

Description: The fresh hydrogen sulfide feed is compressed and combined with a recycle hydrogen sulfide stream from the fractionation section. Methanol is injected into the combined hydrogen sulfide stream, and the total feed is vaporized before entering the fixed-bed reactor. The reactor effluent is partially condensed and flows to the separator drum where three phases are separated: a vapor phase, a water phase, and a lighter mercaptan-rich phase.

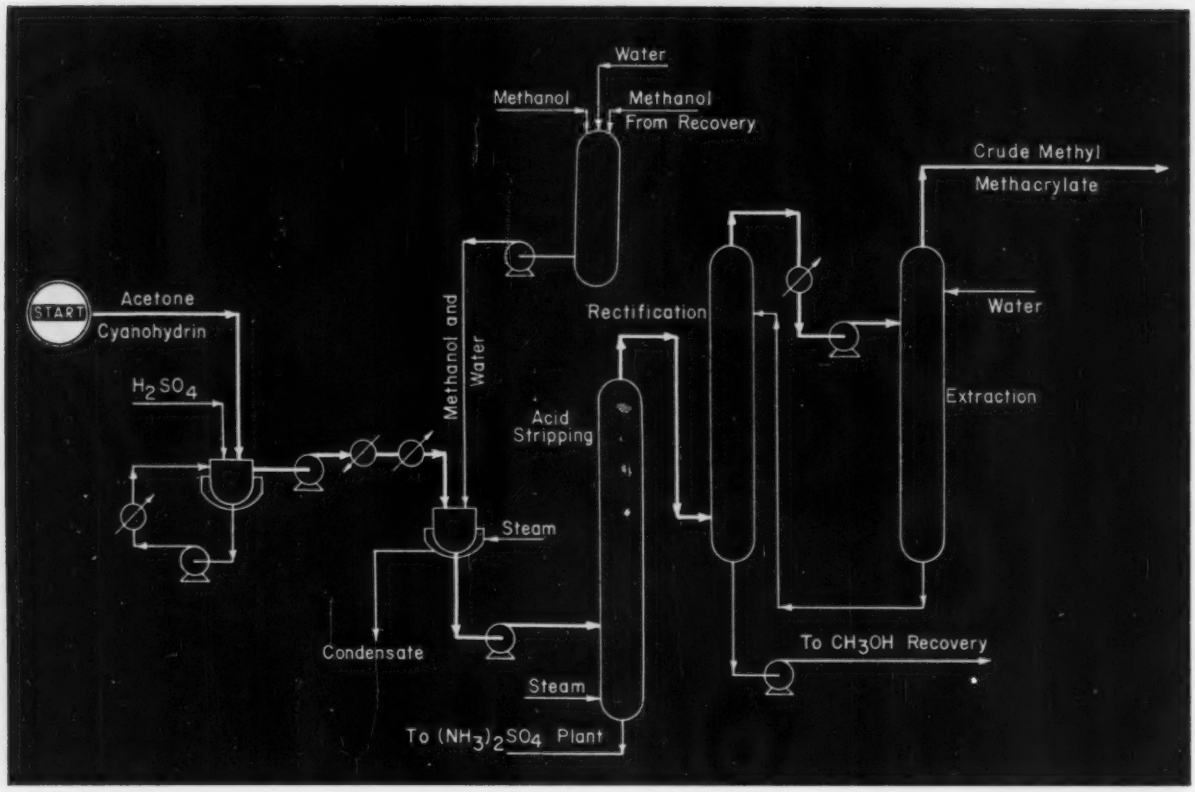
The gas phase consisting largely of light hydrocarbons and carbon dioxide received in the hydrogen sulfide feed is vented to the waste furnace. The mercaptan phase is separated by decantation and pumped to the stabilizer column, where the unreacted hydrogen sulfide, together with reaction byproducts and other components lighter than methyl mercaptan are removed and recycled to the reactor feed. A part of this stream is discarded to the waste system as necessary to control the concentration of light contaminants in the system.

Bottoms from the stabilizer tower is charged to the second tower where the methyl mercaptan product is taken overhead and dried. The bottom stream consisting principally of dimethyl sulfide, ethyl and isopropyl mercaptan. water and unconverted methanol is run down to the waste disposal furnace.

The synthesis step of the production of methyl mercaptan is carried out at a temperature of 600°-625° F and a pressure of 300-350 psig over alumina catalyst. The molar yield of methyl mercaptan on methanol is 64-71 percent.

Because of toxicity and obnoxious odor, both the hydrogen sulfide feed and methyl mercaptan product present handling problems. A waste disposal furnace is provided to burn all byproduct streams.

Commercial Installation: This process for making methyl mercaptan has been in use since 1955 at the Texas City plant of Amoco Chemicals Corporation.



Methyl Methacrylate Monomer — ROHM & HAAS COMPANY

Application: This is a process for the manufacture of methyl methacrylate monomer.

Charge: The raw materials for this process consist of acetone cyanohydrin, sulfuric acid and methanol.

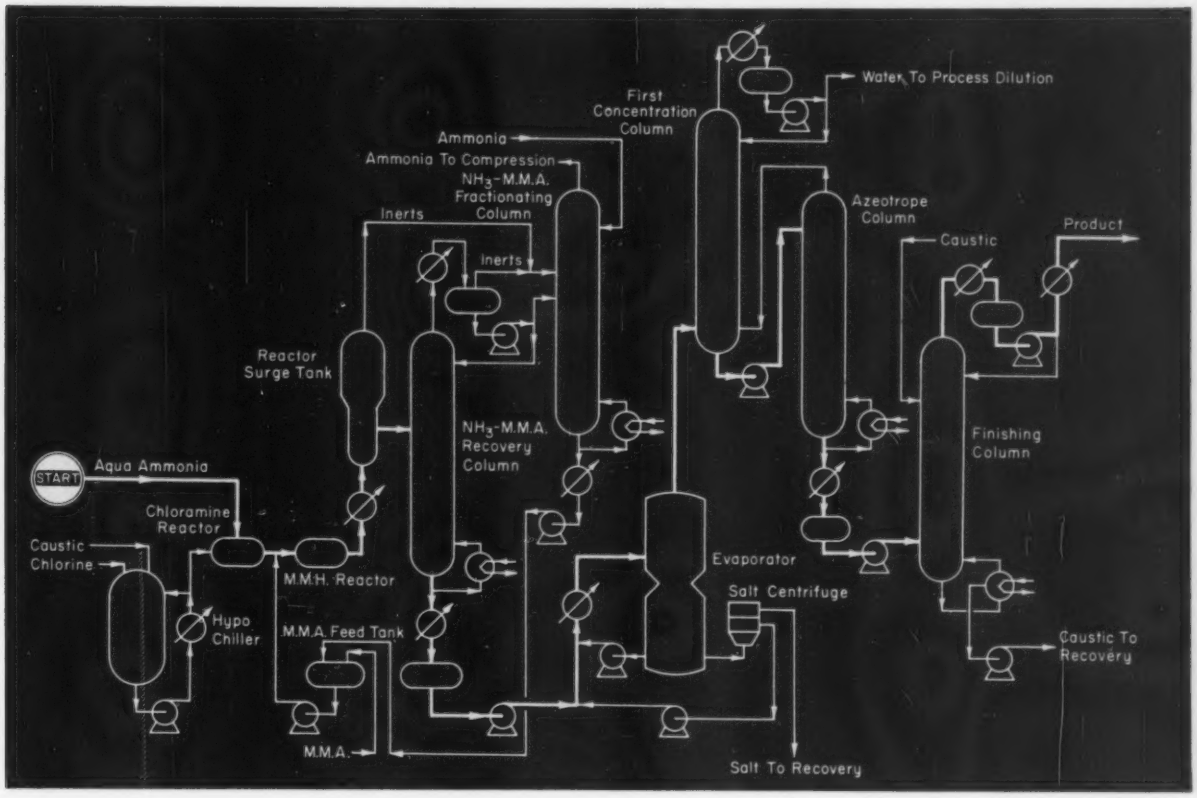
Products: The product is methyl methacrylate monomer.

Description: The process represents the method used for the manufacture of methyl methacrylate, starting with acetone cyanohydrin (prepared by the reaction of hydrogen cyanide and acetone). The acetone cyanohydrin and 99 percent sulfuric acid are reacted to form a methylacrylamide sulfate intermediate. This intermediate is not isolated but is reacted with dilute methanol solution to produce the methyl methacrylate monomer in a continuous manner. The acetone cyanohydrin and concentrated sulfuric acid are pumped into a cooled reaction kettle to form the intermediate. The stream leaving this reaction kettle is dehydrated by heating it in exchangers to an elevated temperature. The stream is then cooled and passed into a series of esterification kettles. In the esterification kettles dilute methanol is added and the methyl methacrylate is formed. In order to prevent polymerization, inhibitors are added at various points in the process. The esterified stream is then pumped to the acid stripping column where methyl methacrylate, methanol and some water are taken off overhead, and the residue, consisting of excess sulfuric acid, ammonium bisulfate and water, is sent to the ammonium sulfate plant. The overhead stream from the acid stripping column enters the rectifier column where the methyl methacrylate and some methanol are removed at the top. This material is condensed and sent to the wash column where the methyl methacrylate is separated from the methanol. The water solution from the bottom of the wash column is returned to the rectifier column, and the bottoms from the rectifier column, consisting essentially of water and methanol, are sent to the methanol recovery column. Recovered methanol is recycled to the esterification kettle and the water is sent to waste. The crude methyl methacrylate, free of methanol, comes from the top of the wash column. The methyl methacrylate is further purified by distillation in a three-stage column system similar to that used for the preparation of the methyl and ethyl acrylate (see p. 269).

Operating Conditions: The principal operating conditions have been mentioned in the description above.

Commercial Installations: The Rohm & Haas Company has constructed two units at Houston, Texas, one unit at Bristol, Pa., and one unit at Louisville, Kentucky, employing this process.

Reference: *Ind. Eng. Chem.*, **51**, 1232, 1328 (1959).



Monomethyl Hydrazine — OLIN MATHIESON CHEMICAL CORPORATION

Application: A process for the manufacture of monomethyl hydrazine (MMH).

Charge: Dilute caustic soda (12 percent), chlorine, aqua ammonia (5 percent), and monomethylamine.

Product: Anhydrous monomethyl hydrazine, 98-99.5 percent. This chemical is a strong reducing agent which is readily oxidized. It is an endothermic compound which is hypergolic with oxidizers such as fluorine and nitrogen tetroxide. It is therefore receiving much attention as a storable liquid propellant for rocket and ballistic missile applications.

Description: Liquid chlorine and pre-cooled dilute caustic soda are mixed to form sodium hypochlorite solution. Hypochlorite preparation is continuous and is automatically controlled by means of oxidation potential. (Close control of residual caustic is necessary to prevent NaOH build-up in the salt evaporator.)

An excess of aqua ammonia is reacted with hypochlorite to form chloramine. The chloramine reacts with monomethylamine in a reactor specially designed to stimulate the formation of monomethyl hydrazine (hereafter referred to as MMH). Closely controlled conditions carry this reaction to completion. The synthesis reactions are:

$$Cl_2 + 2\,NaOH \rightarrow NaOCl + NaCl + H_2O$$

$$NaOCl + NH_3 \rightarrow NH_2Cl + NaOH$$

$$NH_2Cl + NaOH + NH_2CH_3 \rightarrow NH_2 \cdot NHCH_3 + NaCl + H_2O$$

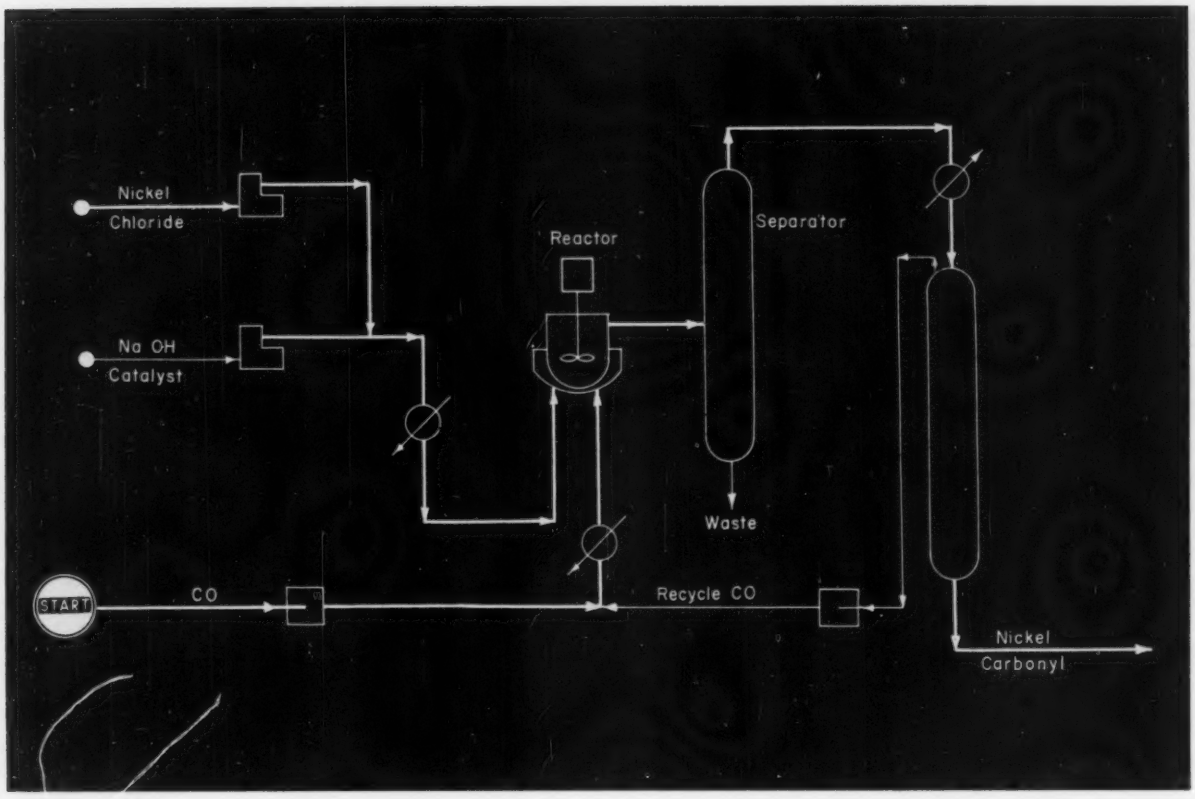
The reactor effluent containing a dilute aqueous solution of MMH together with sodium chloride, excesses of methyl amine and ammonia, and nitrogen, goes to a surge tank. Nitrogen gas, containing ammonia and methylamine vapor, is purged from the top of this tank to the NH_3-MMA fractionating column. MMH reactor pressure, a contributing factor to higher yields, is controlled by the inerts purge from this tank. The water solution of MMH, NaCl, MMA, and NH_3, is separated in the ammonia-methylamine recovery column with MMH, salt, and water remaining in the bottom and ammonia and methylamine going overhead. The ammonia and MMA are condensed, held in a reflux tank (inerts from reflux drum are also purged to NH_3-MMA fractionating column), and then go to the NH_3-MMA fractionating column where the MMA is taken as bottoms, cooled and routed back to the MMA feed tank. Ammonia and nitrogen are taken overhead, compressed, condensed, and stored. The accumulated nitrogen inerts from ammonia storage are passed through a water scrubber where ammonia is removed as aqua ammonia which is recycled to the chloramine reactor. The nitrogen is collected, stored, and used for padding operational equipment, storage tanks, and the shipping containers.

The bottoms of the NH_3-MMA recovery column containing MMH, water, and salt are cooled and fed to an evaporator. Here, salt is crystallized and removed by centrifuging. The water and MMH overhead vapor from the evaporator goes to a concentration system consisting of three distillation columns. The entire concentration system is operated under nitrogen atmosphere padding to prevent formation of an explosive mixture of vapors. The first column yields as overheads distilled water which is condensed and used for caustic dilution and aqua ammonia make-up. The bottoms product is MMH solution which is fed to the second concentration column. Overhead vapors from this column are fed to the first concentration column. The bottoms product from the second column is the MMH azeotrope which is fed to the finishing column. In this column the azeotrope is broken with caustic soda. The finished product is taken overhead, condensed, cooled and stored. Dilute caustic from the bottom is reconcentrated, cooled and recycled back to the column.

Operating Conditions: Not available.

Yields: Over-all yields depend upon operating conditions and production capacity.

Commercial Installations: This process is used by Olin Mathieson Chemical Corporation, Lake Charles, La.



Nickel Carbonyl— ROHM & HAAS COMPANY

Application: A process for the manufacture of nickel carbonyl.

Charge: Aqueous nickel chloride brine, aqueous sodium hydroxide, carbon monoxide gas, and a catalyst.

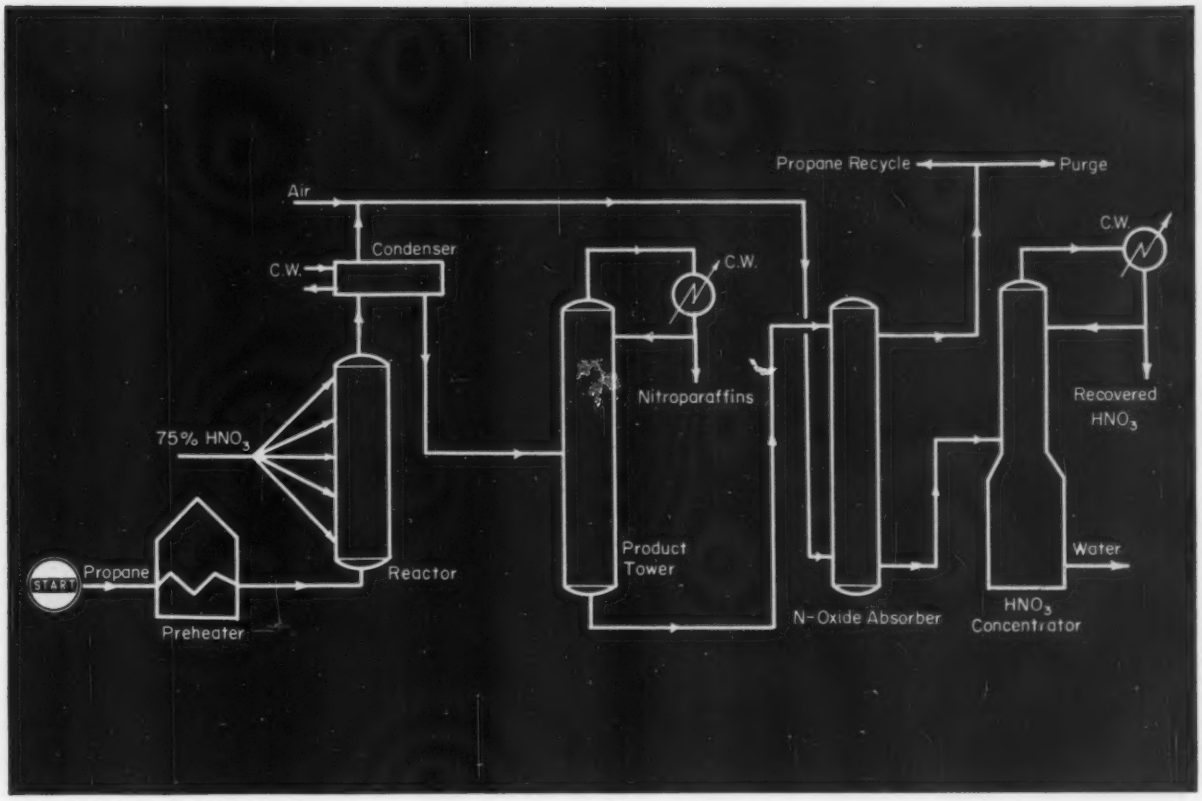
Products: The product is essentially pure nickel carbonyl, an extremely toxic material.

Description: This process represents an economical method for the production of nickel carbonyl, for use in the manufacture of methyl or ethyl acrylate from acetylene. The nickel chloride solution is obtained as a recycle stream from the synthesis of the acrylate plus a small amount of new solution to make up for the mechanical and chemical losses in the process. The catalyst used is dissolved in the sodium hydroxide solution. The solutions of nickel chloride and sodium hydroxide are pumped through high-pressure injection pumps, and the carbon monoxide is compressed in a four-stage compressor. Nickel carbonyl is produced by mixing the solutions with the carbon monoxide at a high pressure in a reactor provided with good agitation. The temperature is maintained above 100° C and the nickel carbonyl leaves the reactor with an excess of carbon monoxide. The carbonyl is condensed and stored under refrigeration and under an atmosphere of carbon monoxide. Excess carbon monoxide is recycled through the process. Inert gases, such as argon, nitrogen and methane, which accumulate in the gas stream must be vented to maintain the partial pressure of carbon monoxide above 1500 psi. The liquid slurry from the reaction is discarded after being treated to remove all of the nickel carbonyl. The waste gas streams are passed through a decontamination furnace where they are heated to destroy the nickel carbonyl. This venting of the inert gases provides the major loss of nickel carbonyl, but in spite of this, the yield of carbonyl based on nickel is high.

Operating Conditions: The reactor operates at a carbon monoxide partial pressure above 1500 psi and a temperature above 100° C.

Commercial Installations: Two units have been constructed at the Rohm & Haas plant in Houston.

Reference: *Ind. Eng. Chem.*, **51**, 1232, 1328 (1959).



Nitroparaffins

Application: A process for the manufacture of nitroparaffins from propane.

Charge: Propane and 75 percent nitric acid.

Products: Nitromethane, nitroethane, 1-nitropropane, and 2-nitropropane.

Description: Propane gas is heated to 430°-450° C in a furance and enters a glass or silica-lined reactor. The 75 percent nitric acid is sprayed into the gas stream at several points. The amount of acid from each spray is adjusted so that the heat of vaporization of the water in the acid counteracts the exothermic heat of the reaction to maintain the temperature at 390°-440° C. The over-all mole ratio of propane: nitric acid is 5:1, with the stagewise addition limiting the ratio at any one stage to 25:1.

It is important that pyrolytic temperatures be avoided in order to prevent carbon skeleton rearrangements. At the proper nitration temperatures some decomposition of the various nitrated and oxidized compounds does not occur and therefore some olefins and degrated products are formed. The pyrolysis of nitroethane and 1-nitropropane gives olefins, aldehydes, carbon dioxide, and nitrogen.

Nitric acid and nitrogen dioxide give the same products, but nitric acid gives better yields and higher nitration rates. Comparison of various reaction rate studies shows that the substitution of any hydrogen atom can be effected more readily by nitric acid than by nitrogen dioxide. Some experimental runs show four times the yield using nitric acid rather than nitrogen dioxide.

The gas leaving the reactor is cooled in a partial condenser. The nitroparaffins and dilute nitric acid are condensed while propane and gaseous oxidation products pass to recovery units from which recovered propane is recycled. The condensate separates into two layers. The lower dilute nitric acid layer is fed back to the nitrator as makeup, after fortification with fresh nitric acid. The upper nitroparaffin layer is fractionated into the four products of the reaction.

Under the conditions of the reaction the products obtained will represent all possible ones in which the nitro group replaces either a hydrogen or any alkyl group in the hydrocarbon feed. Close control of the reaction is necessary to avoid excessive losses by oxidation.

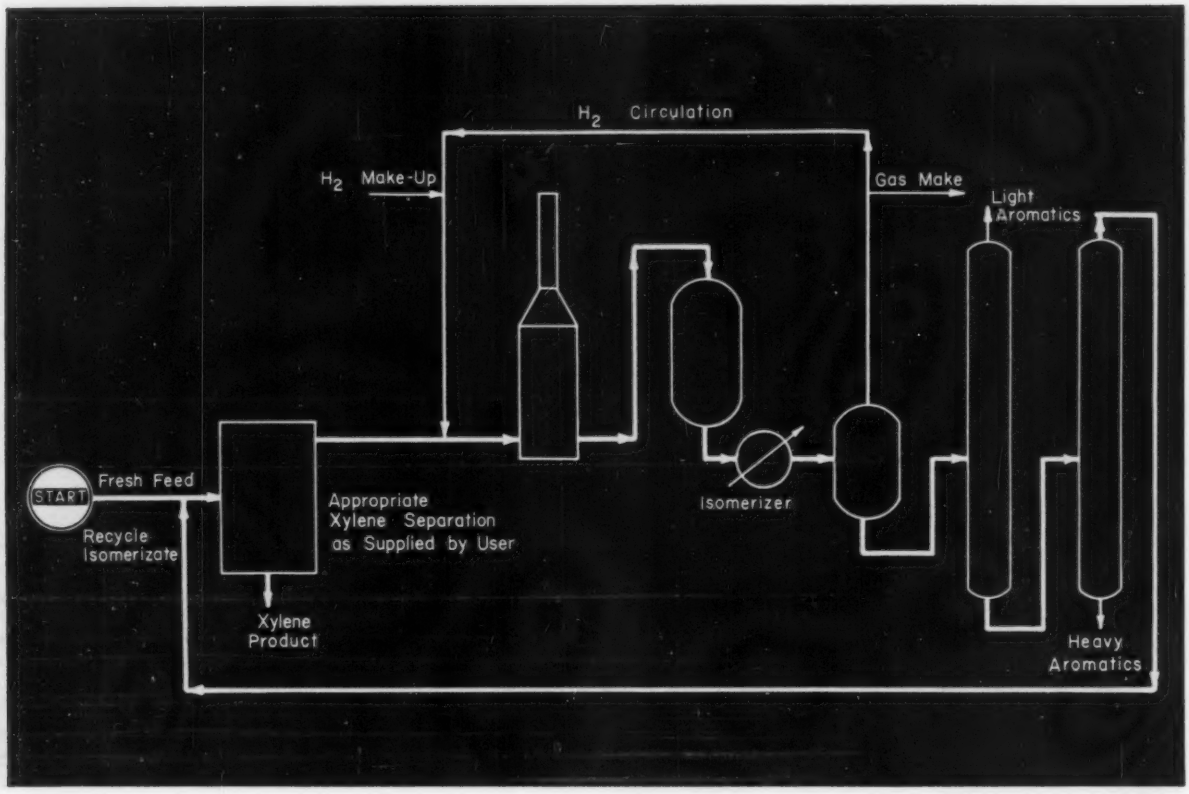
Yields: Yields of 40 percent per pass based on nitric acid conversion to nitroparaffin are reported.

EFFECT OF TEMPERATURE ON PRODUCTS NITRATING PROPANE

PRODUCT	500-510° C. Mole %	790-800° C. Mole %
Nitromethane	22.0	32.2
Nitroethane	16.6	24.2
1-nitropropane	13.2	24.2
2-nitropropane	48.2	19.3

Commercial Installation: This process is in commercial use by Commercial Solvents Corporation at Peoria, Ill.

References: Hass and Schechter, *Industrial and Engineering Chemistry,* 39,p817 (1947). P. H. Groggins (Ed.), *Unit Processes in Organic Syntheses.* 4th Edition,pp2-14 and 77-79. New York, McGraw-Hill Publishing Co., 1952.



Octafining— THE ATLANTIC REFINING COMPANY

Application: A process for making any selected xylene.

Charge: Mixed C_8 aromatics in non-equilibrium concentrations.

Product: *Ortho-, meta-* or *para*-xylene, as desired.

Description: The Octafining process operates on mixtures of C_8 aromatics to bring their concentrations toward an equilibrium value. Therefore, the quantity available of any one of the xylenes can be increased by charging to the Octafining process a mixture of C_8 aromatics in which the concentration of the desired xylene is below the equilibrium value for it in the mix. The Octafining catalyst contains platinum-silica-alumina.

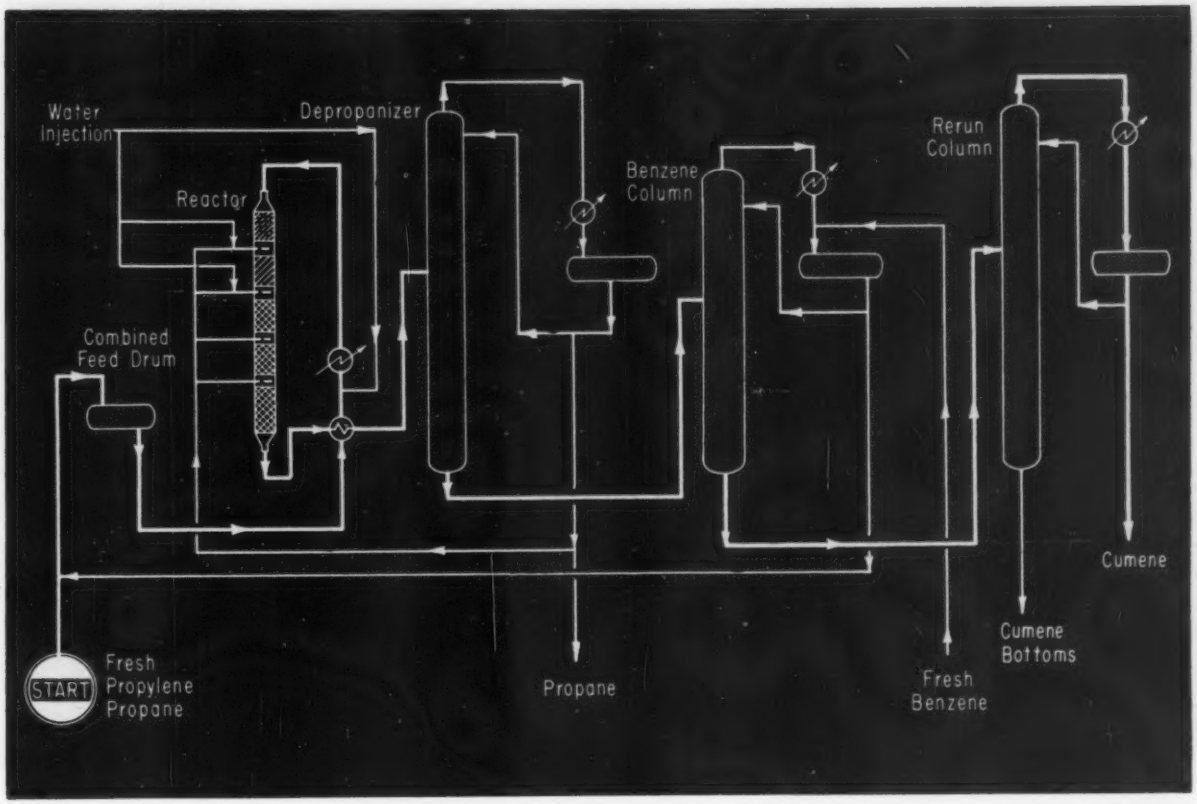
An example of a practical application is to maximize *para*-xylene yield from a mixed C_8 aromatics feed which otherwise would have only a solvent value. In this application, the C_8 aromatics from catalytic reforming and as recycle from the Octafining process would have *p*-xylene removed by crystallization, to give a filtrate containing 7-9 percent *p*-xylene. This filtrate would be mixed with recycle hydrogen and some make-up hydrogen, heated to 750°-950° F at 150-350 psig and passed through Octafining catalyst in the single reactor. Isomerization within the Octafining reactor brings the *p*-xylene content back to its equilibrium value of about 19 percent. Following the Octafining reactor, the isomerizate is cooled, hydrogen separated for recycle and aromatics below and above C_8 removed by fractionation. The remaining C_8 mixture is recycled to join fresh feed ahead of the crystallization. If it should be desired to maximize *ortho-* or *meta*-xylene, a separation step appropriate to the desired isomer would replace the crystallization which in the above example was used to separate the *para*-xylene.

Atlantic's laboratory work indicates that the Octafining catalyst can be used also on C_9 aromatics to isomerize cumene into trimethylbenzene and methylethylbenzene under appropriate operating conditions.

From the discussion above it is readily evident that the yield from a specific application of the Octafining process will be dependent on the composition of the feed, the product desired and the effectiveness of the separation step.

Commercial Installation: The Octafining process, which was developed by The Atlantic Refining Company, is licensed by Engelhard Industries, Inc., who supply the catalyst. The first commercial installation was put on stream in 1960 by Mitsui Petrochemical Industries, Ltd. In conjunction with its crystallizer, it has a rated capacity of 11 million pounds of para-xylene per year.

Reference: *Ind. Eng. Chem.*, Vol. 47'55,p770-3. PETROLEUM REFINER, Aug.,'58,p208.



Olefin-Aromatic Alkylation—UNIVERSAL OIL PRODUCTS COMPANY

Application: A process for alkylating aromatics with olefins. Its principal application is in the manufacture of cumene (isopropylbenzene) by reacting propylene with benzene. The process also is used to make ethylbenzene by alkylating benzene with ethylene.

Charge: Propylene-propane mixture and benzene to produce cumene; ethylene-ethane mixture and benzene to make ethylbenzene.

Process Description: The following description uses the manufacture of cumene as an example.

The olefinic stock is mixed with the benzene in a combined feed surge drum. The resulting charge is pumped to the reaction chamber. The solid phosphoric acid catalyst is maintained in separate beds in the reactor, suitable propane quench being provided between beds for temperature control purposes, since the reaction is exothermic in nature.

The reactor effluent is depropanized. Some if this propane is used for quenching; the blanace is withdrawn as a net product stream.

The depropanizer bottoms stream passes to the benzene recovery column, where unreacted benzene is distilled overhead. It ultimately combines, as recycle, with fresh benzene in the overhead receiver. The fresh and recycle benzene mixture is then pumped from this receiver to the combined feed surge drum.

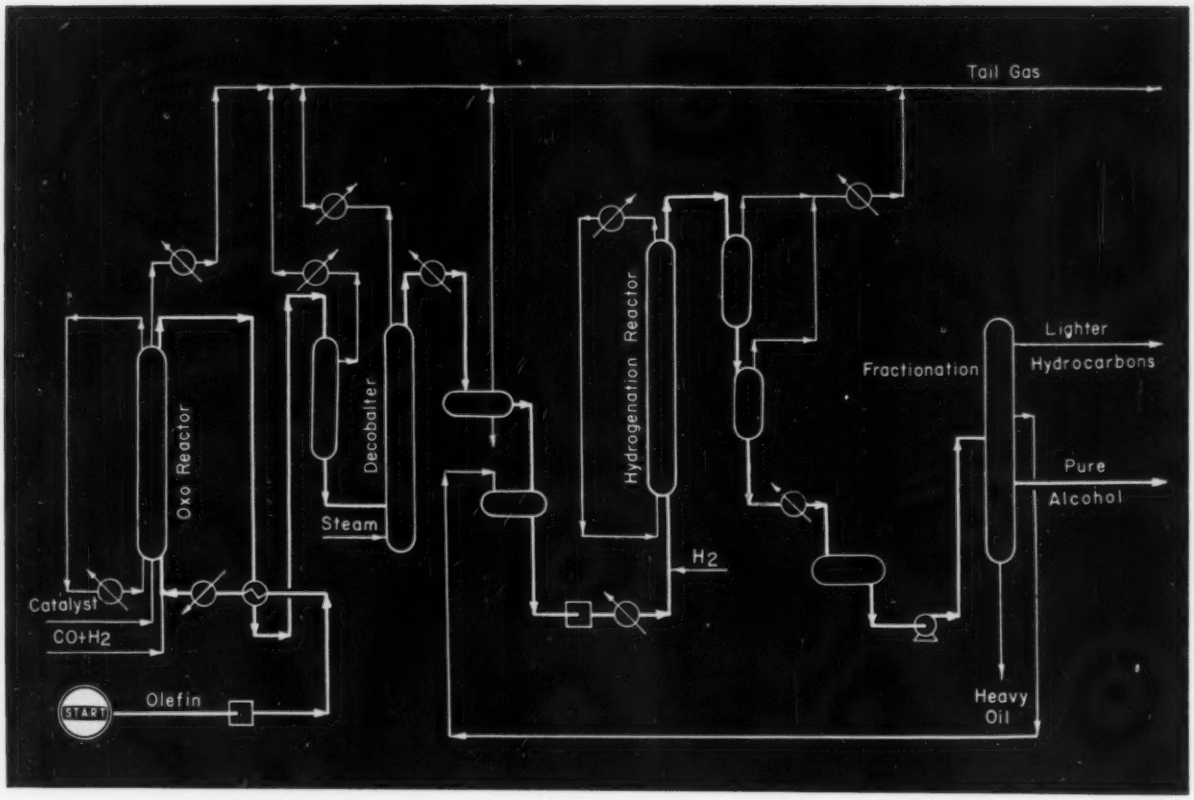
The crude cumene product from the bottom of the benzene column is rerun to produce specification cumene. A minor amount of cumene bottoms also is made.

Essentially the same sequence of operating steps is employed in the manufacture of ethylbenzene. However, minor modifications are necessary as the consequence of the introduction of ethane and other light, non-condensable gases with the olefin feed. Process equipment, arranged for the most part as in the flow diagram shown, also is suitable for making diisopropylbenzenes and butylbenzenes. Appropriate modifications to the reaction conditions are required to produce these other alkylaromatics.

Yields: The yields in bpsd from typical cumene operations are: propane charge 75, propylene charge 70, benzene charge 72, propane product 75, propylene product 2, cumene 100 and bottoms 4.5

Commercial Installations: There are many installations employing this process. Numerous units produce cumene of high purity (over 99.4 percent) for subsequent use in manufacturing phenol and acetone. Still others have been constructed to make ethylbenzene.

Reference: Jones, E. K., "Polymerization of Olefins from Cracked Gases," p. 219-238, *Advances in Catalysis,* VIII, Academic Press, New York (1956).



Oxo Process (Ruhrchemie AG)—HOECHST-UHDE CORPORATION

Application: A process for the production of aldehydes and alcohols from olefins, carbon monoxide and hydrogen.

Description: The reactions to produce oxo alcohols are typified by the following equations:

$$R-CH-CH_2 + CO + H_2 = R-CH_2-CH_2-CHO$$
$$R-CH_2-CH_2-CHO + H_2 = R-CH_2CH_2CH_2OH$$

In the initial process step, the feed olefin reacts with carbon monoxide and hydrogen in the presence of a cobalt catalyst to produce an aldehyde having one more carbon atom than the olefin. The catalyst is in a form which does not introduce any materials not related to the process. The reaction is strongly exothermic and the heat of reaction is removed in an indirect cooling cycle.

The raw aldehyde leaving the oxo reactor is treated with steam at a higher temperature to convert the cobalt catalyst to a form in which it can easily be separated from the reacted mixture. This treatment also results in decomposition of undesirable byproducts formed in the reactor.

If the oxo alcohol is the desired product, the raw aldehyde is hydrogenated in the presence of a nickel catalyst. The raw alcohol is then fed to a distillation section comprising a number of fractionating columns operating in series. A light hydrocarbon steam and a heavy oil are obtained as byproducts, in addition to the purified alcohol.

The most important process conditions are summarzied as follows:

Synthesis:

Hydrogen to carbon-monoxide ratio	1.2:1.0
Catalyst	0.5-1% cobalt
Temperature	170-175° C
Pressure	250 Atm.
Olefin Conversion	95%

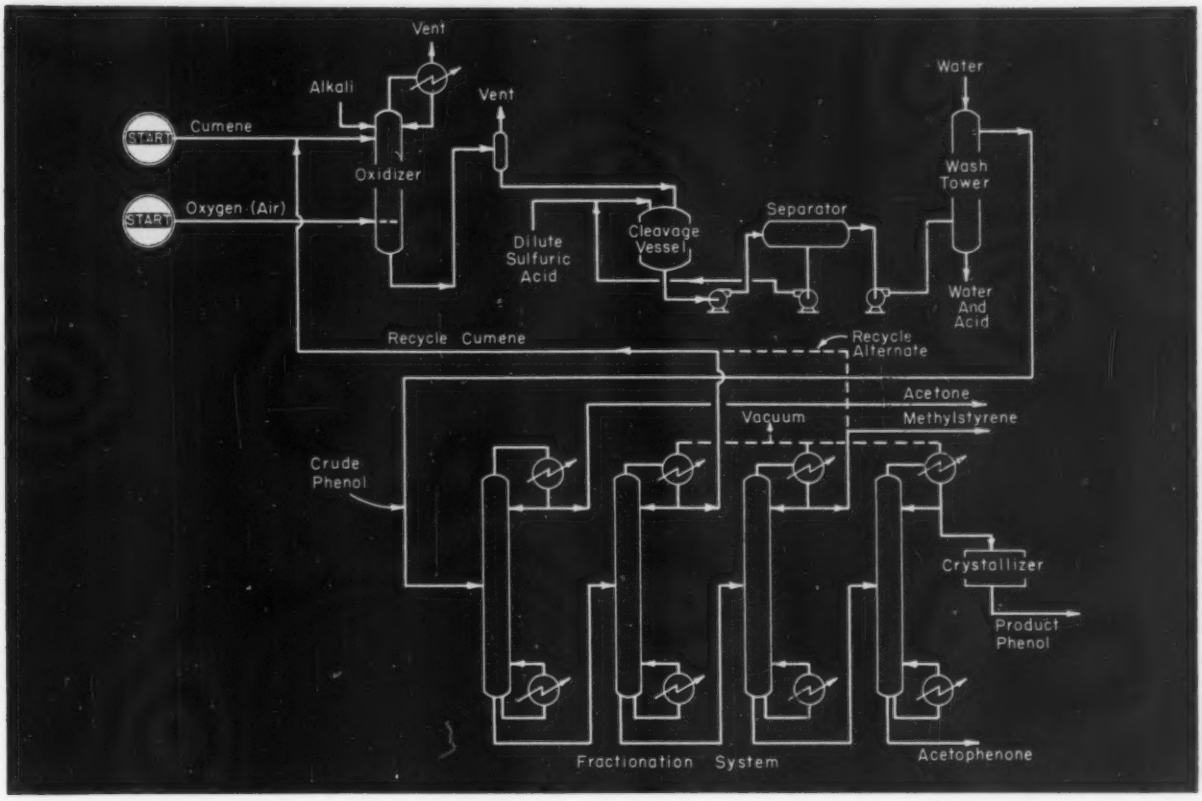
Decobaltization:

Temperature	180° C
Pressure	20 Atm.

Hydrogenation:

Temperature	150° C
Pressure	100 Atm.
Typical alcohol yield	85-90 lb. iso-octanol from 100 lb. heptene

Commercial Installation: The process is in commercial use at Ruhrchmie AG, Oberhausen-Holten, Germany.



Phenol from Cumene

Application: A process for manufacturing synthetic phenol from cumene.

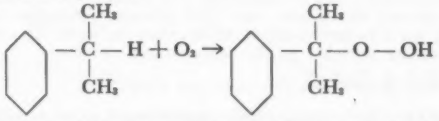
Charge: Cumene (isopropylbenzene), 99 percent purity; air dilute sulfuric acid.

Product: Phenol (42.5°-43° M m.p.), acetone, α-methylstyrene, acetophenone.

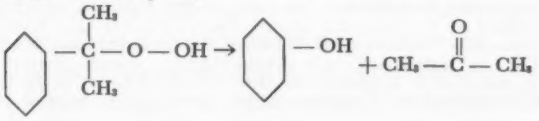
Description: The primary raw material for this process is cumene; methods for its manufacture are described elsewhere in this handbook. The cumene is treated to remove unsaturated and other materials likely to catalyze decomposition of peroxide during the oxidation step.

Oxidation is carried out in special contactors designed for intimate mixing of gas and liquid. Air is passed countercurrent to cumene (fresh and recycle) to which an alkali such as sodium carbonate is added. Reactor contents are maintained at about 260° F, a pressure slightly above atmospheric, and a pH in the 8.5-10.5 range. Surfactants and other special additives are used to promote effective utilization of oxygen in the air. Vent gases from the contactor pass to a condenser where cumene and other organics are recovered. (Since conversion of cumene is relatively low in the oxidation step, one process alternate calls for topping recycle cumene at this point.) Special precautions are necessary in order to avoid explosive concentrations of peroxides.

In the oxidation step cumene hydroperoxide is produced according to the reaction:



Effluent from this step passes to a cleavage vessel where the peroxide is decomposed:



Cleavage to phenol and acetone is caused by the action of dilute sulfuric acid (10-25 percent); contacting takes place in an agitated vessel at about 130°-150° F. Decomposition is essentially complete. The reaction products form acid and oil layers which are separated; the acid layer is recycled to the cleavage vessel.

The oil layer is scrubbed with water in a packed tower, giving a crude phenol mixture as follows:

	Wt.-Percent
Acetone	8
Cumene	76
α-Methylstyrene	1
Phenol	14
Acetophenone	1

This mixture is separated in a series of conventional distillation columns. In the first column, acetone is removed and refined as required for sales. The second and third columns, operated under vacuum, separate cumene for recycle and methylstyrene for sales or recycle. If the latter material is recycled, it must be converted to cumene by a hydrogenation conveniently carried out in the presence of suspended Raney nickel catalyst.

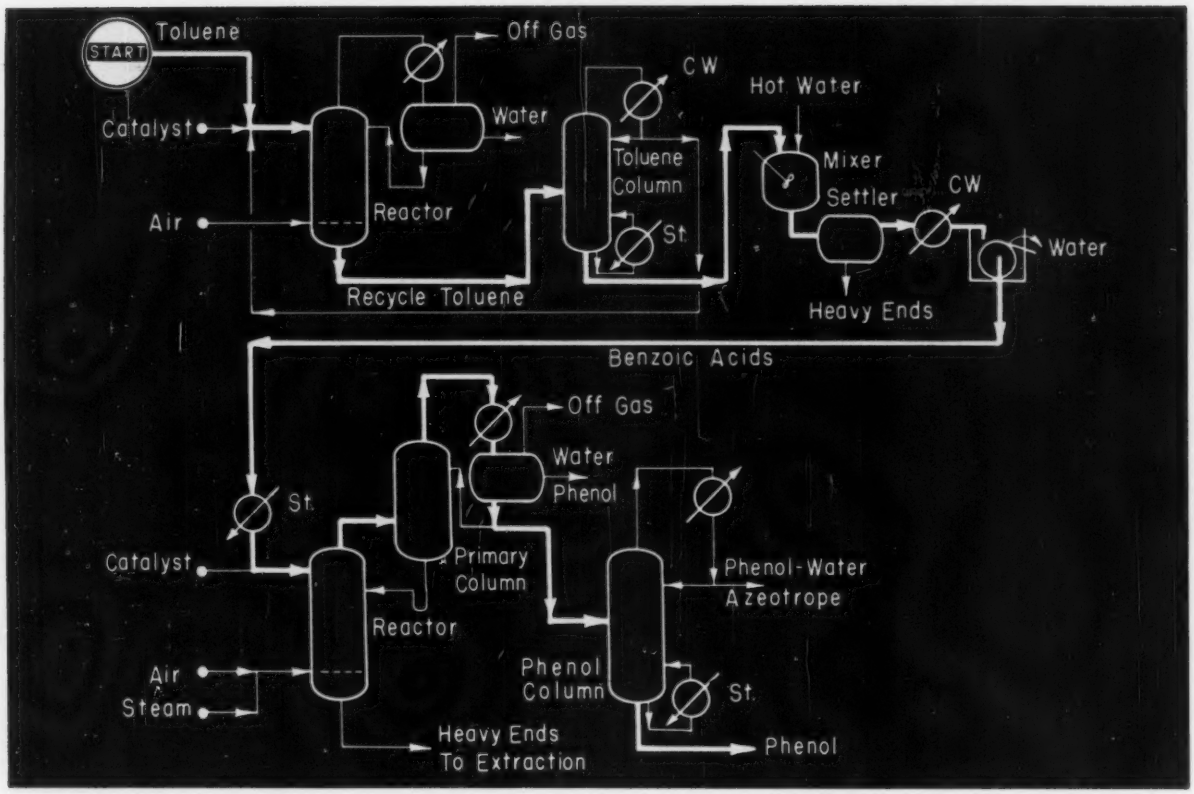
The final vacuum fractionator separates product phenol overhead which is further purified by crystallization. The bottom material from this column contains acetophenone in admixture with small amounts of phenol and tars. Further purification of this material may be required by customer specifications.

An important feature of the cumene phenol process is that substantial quantities of acetone are produced. The credit for this by-product strongly influences the competitive economics of this process for manufacturing phenol.

Operation Conditions: Given in the above text.

Yields: The over-all process yield, from raw material cumene to finished phenol, is about 93 percent of theory.

Commercial Installations: British American-Shawinigan, Ltd., Montreal East, Canada; Allied Chemical Corp., Frankford, Pa.; Hercules Powder Co., Gibbstown, N. J.; Oronite Chemical Co., Richmond, Calif.; Shell Chemical Co., Houston (Deer Park), Texas.



Phenol from Toluene

Application: A process for manufacturing synthetic phenol from toluene.

Charge: Air; toluene, 99+ percent purity (230-232° F Boiling Range).

Product: Phenol, 108.5-109.5° F Melting Point.

Description: This process is based on the two-stage, liquid-phase oxidation of toluene. Air is the oxidizing agent, and benzoic acid is produced in the first stage. In the second stage, the acid is further oxidized to phenol.

In the first stage, fresh and recycle toluene are mixed with a small portion of cobalt naphthenate catalyst and charged to the reactor. The reactor is a liquid-filled tower through which air is sparged. Cooling tubes are provided for removing the exothermic heat of reaction.

Benzoic acid is produced by the autoxidation of toluene:

$$C_6H_5CH_3 + 1\frac{1}{2}\ O_2 \rightarrow C_6H_5COOH + H_2O$$

The reaction medium is maintained at about 300° F and 25-35 psig. An excess of air is used, but toluene conversion is limited to about 40 percent. The yield of benzoic acid is on the order of 90 percent, with principal byproducts being benzaldehyde, benzyl alcohol, and benzyl benzoate. Small amounts of CO and CO_2 are also produced.

Off gases from the reactor pass to a water-cooled condenser and thence to a final recovery system, toluene and water being collected in both steps. The toluene is separated and recycled.

Liquid from the reactor passes to a distillation column where toluene (and benzaldehyde) are taken overhead for recycle. Bottoms from the column are extracted by washing with hot water. The aqueous layer is separated and cooled to precipitate the benzoic acid. The latter material is filtered and washed prior to its being used in the second-stage oxidation. The acid could be further purified to meet USP specifications.

In the second stage, benzoic acid is melted, mixed with a small portion of cupric benzoate catalyst, and charged to the reactor. Small amounts of promoters such as magnesium benzoate are also added to the charge. The reactor is a liquid-filled tower containing cooling tubes and mechanical agitators. A mixture of air and steam is sparged to the base of the reactor.

Phenol is produced by the oxidation of benzoic acid:

$$C_6H_5COOH + \frac{1}{2}\ O_2 \rightarrow C_6H_5OH + CO_2$$

The reaction medium is maintained at about 450° F (232° C) and 5-10 psig. Excess air is used, and benzoic acid conversion is 70-80 percent. The yield of phenol is on the order of 90 percent.

Phenol and benzoic acid are vaporized continuously and pass overhead from the reactor to a distillation column wherein the benzoic is removed and returned to the reactor. Phenol and water are condensed overhead and form two liquid layers. Noncondensibles (O_2, N_2, CO_2) are cooled for further organics recovery and then vented.

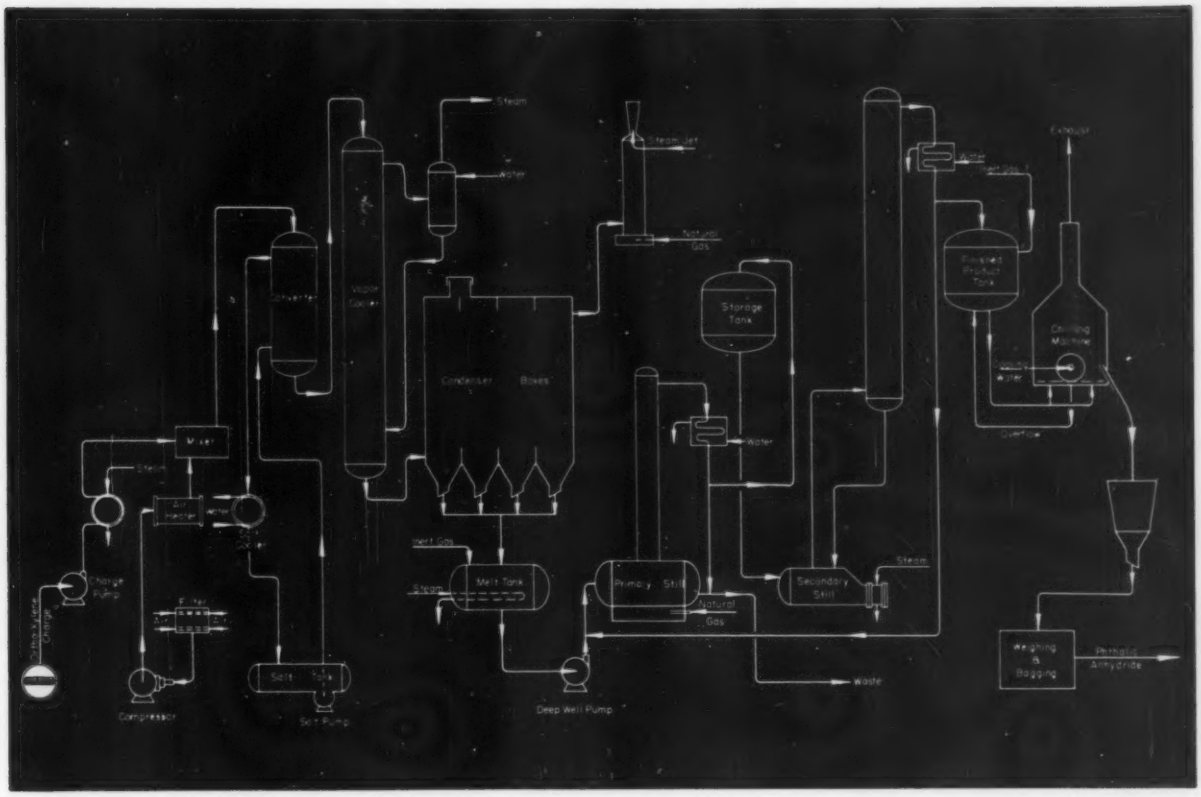
Product phenol is obtained from the phenol-rich layer of the primary column. It is removed as bottoms from an azeotropic column, and further purified as needed to meet USP requirements. Phenol is also recovered from the primary column and azeotropic column water-rich streams by further fractionation.

Bottoms from the second-stage reactor are water-extracted for their content of benzoic acid and phenol. Alternate extracting agents, such as methanol or ether, may be used. The recovered organics are recycled to the second-stage reactor.

Operating Conditions: Given in the above text.

Yields: Over-all process yield, phenol from toluene, is about 80 percent.

Commercial Installations: Processes of this type are now being installed at the following plants: Dow Chemical Co., Kalama, Wash. and Vancouver, B. C. It is also reported that a large plant at Rotterdam, the Netherlands, owned jointly by Staatsmijnen in Limburg and Dow Chemie A.G., is being built to produce phenol from toluene by this processing method.



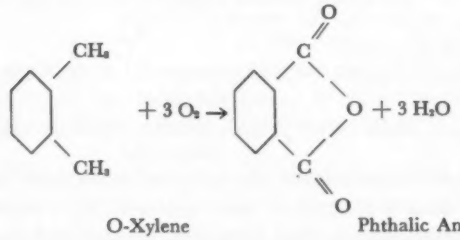
Phthalic Anhydride— CALIFORNIA RESEARCH CORPORATION

Application: This process is applied to the manufacture of phthalic anhydride.

Charge: The charge is ortho-xylene.

Product: The product is solid phthalic anhydride.

Description: The liquid ortho-xylene feed is pumped at controlled rates into vaporizers. The vaporized xylene is fed to a mixer where it is contacted with heated air. This mixture then goes to salt-cooled converter units where the following reaction occurs:



O-Xylene Phthalic Anhydride

This direct oxidation of the xylene to phthalic anhydride is promoted by the catalyst in the converter tubes which is based on vanadium pentoxide (V_2O_5). This catalyst must be carefully prepared for proper catalyst activity.

The reaction gases leaving the bottom of the converters are cooled to condense crude phthalic anhydride. The spent gases pass into catalytic incinerating furnaces to eliminate fume nuisance.

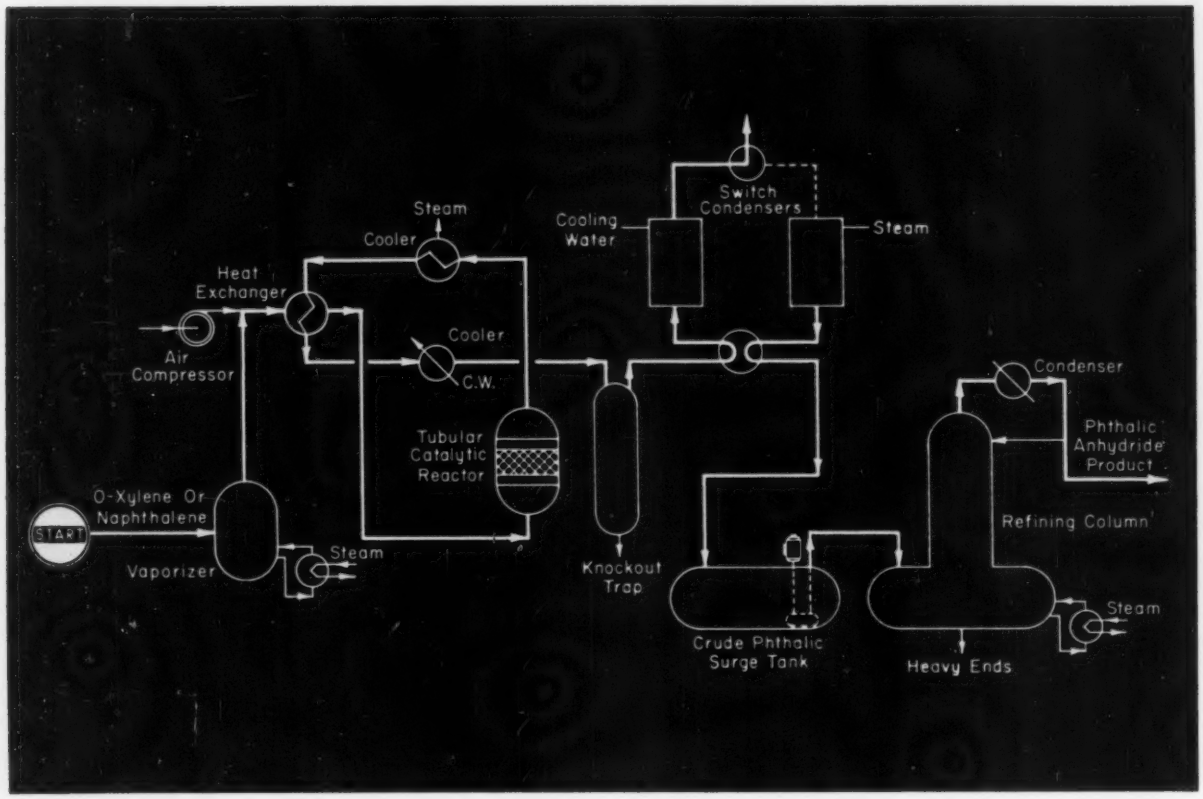
The crude phthalic anhydride goes to melt tanks for storage. The molten anhydride is distilled batchwise in two distillation stills in series. Light boilers such as benzoic acid are taken off under vacuum as a heads cut. The purified phthalic anhydride is removed as a heart cut from the second still which also operates under vacuum. The product goes from the secondary still to an aluminum storage tank. From this tank it is fed to a stainless-steel water-cooled surface for solidification. The final product in the form of chips is weighed and packed in paper bags. Molten anhydride also is shipped in steam-heated tank cars.

Operating Conditions: The most important operating conditions are the air/hydrocarbon ratio, the temperature in the converter and the contact time. Typical operating ranges for these variables are given below:

Air/Hydrocarbon Ratio	18-20
Temperature, F.	900-1150
Contact Time, Seconds	0.1-0.15

Commercial Installation: Oronite Chemical Company, Richmond, Calif.

Reference: PETROLEUM REFINER, Oct.'53,p113; *Chemical Engineering Progress,* Apr.'47,p167.



Phthalic Anhydride— SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of phthalic anhydride.

Charge: Naphthalene and/or ortho-xylene.

Product: High purity phthalic anhydride.

Description: Phthalic anhydride is best produced from naphthalene in a fixed-bed catalytic vapor phase reaction. In sequence, the feedstock, comprising naphthalene, *o*-xylene, or mixtures thereof, is vaporized, mixed with air, preheated by exchange with effluent gases, and fed to the reactor. The reactor cooling system (not shown) consists of molten salt circulating outside the tubes of the reactor.

Reaction effluent gases containing phthalic anhydride vapor are first cooled by a waste heat boiler generating steam, then used to preheat the feed mixture, and finally are cooled with cooling water to a temperature a few degrees above the dew point of phthalic anhydride. After leaving this cooler, the gases are passed through one of a pair of highly efficient switch condensers of novel design which condense solid crystals of phthalic anhydride. The condenser effluent gases, which may contain traces of by-products, are burned or water-scrubbed before release to the atmosphere. Meantime, in the alternate switch condenser, phthalic anhydride from the previous cycle is being melted out. The crude phthalic anhydride is treated to destroy contaminants and is then distilled under vacuum. The refined product may be flaked, pelletized, or packaged for shipment in liquid-full steel drums or tank cars. Fumaric acid may be recovered from the maleic anhydride content of the off-gas scrubber liquor.

Chemical Reactions.

Main Reaction—

a) $C_{10}H_8 + 4\frac{1}{2}\ O_2\ (air) \rightarrow C_8H_4O_3 + 2\ CO_2 + 2\ H_2O$

b) $C_8H_{10} + 3\ O_2\ (air) \rightarrow C_8H_4O_3 + 3\ H_2O$

Principal Side Reaction—

a) $C_{10}H_8 + 12\ O_2\ (air) \rightarrow 10\ CO_2 + 4\ H_2O$

b) $C_8H_{10} + 10\frac{1}{2}\ O_2\ (air) \rightarrow 8\ CO_2 + 5\ H_2O$

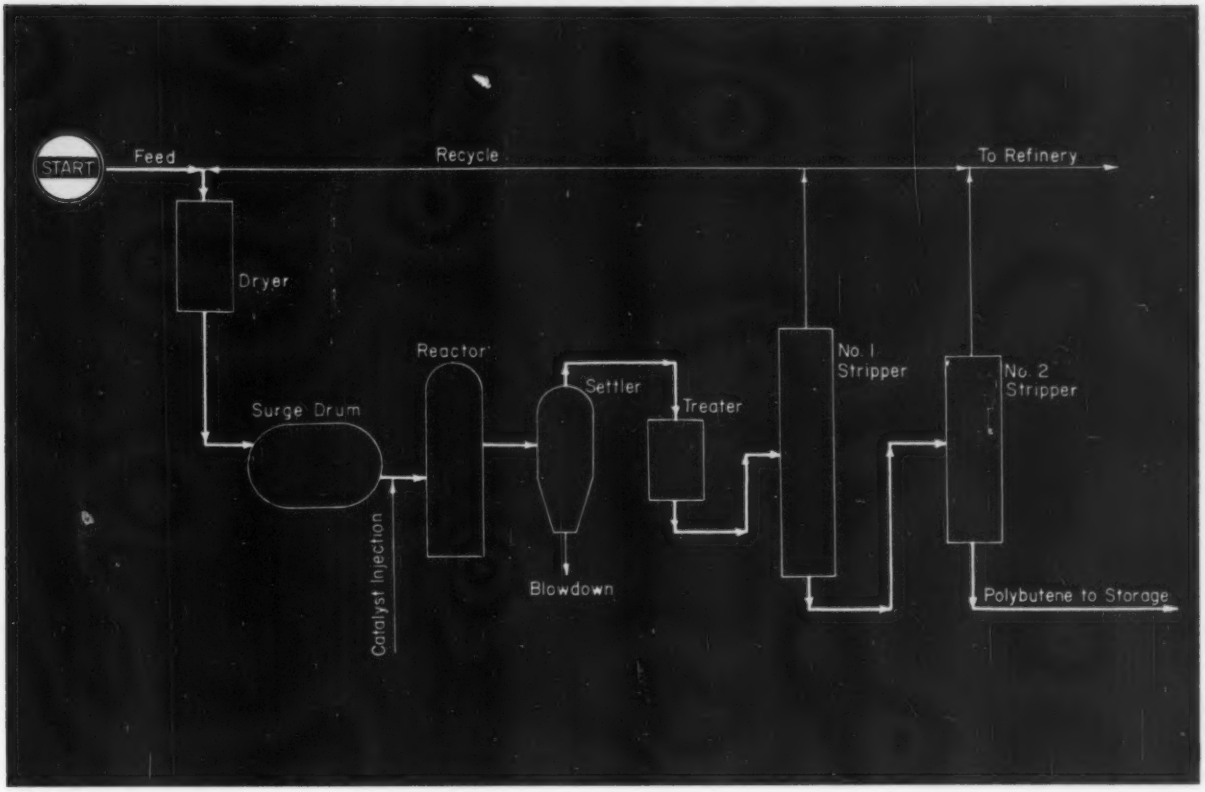
Minor Side Reaction—

a) $C_{10}H_8 + 9\ O_2\ (air) \rightarrow C_4H_2O_3\ (Maleic\ Anhydride) + 6\ CO_2 + 3\ H_2O$

b) $C_8H_{10} + 7\frac{1}{2}\ O_2\ (air) \rightarrow C_4H_2O_3\ (Maleic\ Anhydride) + 4\ CO_2 + 4\ H_2O$

Note that almost all side reactions are much more exothermic than the desired main reaction. SD's highly selective oxidation catalyst thus aids temperature control and permits higher thruput rates in the reactor.

Commercial Installations: Witco Chemical Co., Chicago, Ill.; Compagnie Francaise des Matieres Colorantes, Villers-St. Paul, France; Staatsmijnen in Limburg, Geleen, Holland; and Witco Chemical Co., Perth Amboy, N. J.



Polybutene— COSDEN PETROLEUM CORPORATION

Application: Processes for manufacturing liquid polybutene (polyisobutylene).

Charge: Light hydrocarbon streams containg isobutylene from cracking, dehydrogenation, or depolymerization process.

Product: Clear, viscous liquid polybutene from 500 to 1500 molecular weight and from 100 to 20,000 SSU viscosity.

Description: Polybutenes are polymerized butylenes of varying molecular weight and viscosity.

Raw material for the process consists of light hydrocarbons from refinery cracking plants and consisting primarily of the butane-butylene fractions, but including small quantities of materials in the C_3 and C_5 ranges.

The reactor feed is a combination of fresh feed and butylene recycle. This feed is first dried and then precooled with reactor effluent. Immediately before entering the reactor a slurry of anhydrous $AlCl_3$ and light polymer is injected, along with gaseous HCl activator, into the feed stream.

The exothermic polymerization reaction begins to take place immediately and heat is removed by an ammonia-cooled refrigeration bundle.

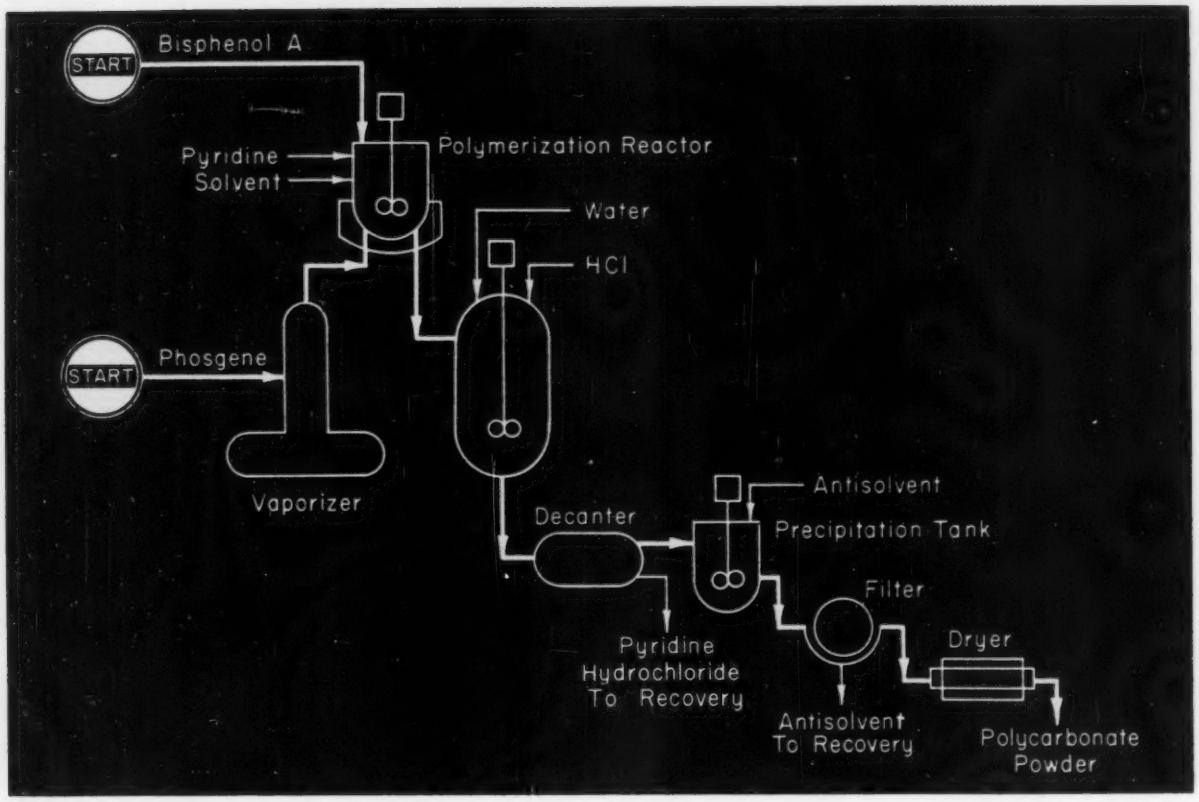
Temperature is a major control for viscosity and molecular weight, with high molecular weight polymers forming at low temperatures and decreasing molecular weights as the temperature is increased.

Effluent from the reactor enters a settler to concentrate the suspended catalyst and return it to the reactor. Spent catalyst is removed by periodic blowdown. The decanted effluent is treated to remove contaminants; then it is fractionated and stripped to recover the polybutene as a clear, viscous liquid with the physical qualities determined by the reactor conditions. Unreacted butylenes are recycled to the reactor feed from the purification section and excess light and heavy hydrocarbon fractions are returned to the refinery for further use.

Polybutene has a number of important industrial applications among which are: the manufacture of calking and sealing compounds, adhesives, vibration dampeners, surgical tapes, electrical insulations, and special lubricants.

Commercial Installations: Amoco Chemicals Corporation, Wood River, Ill., El Dorado, Ark., Yorktown, Va.; Cosden Petroleum Corp., Big Spring, Texas; and Oronite Chemical Co., Richmond, Calif.

Reference: *Chemical Engineering,* Aug. 8, 1960 pp 98-101.



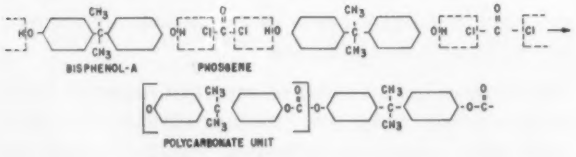
Polycarbonates — GENERAL ELECTRIC COMPANY

Application: A process for manufacturing polycarbonate polymers from Bisphenol-A and phosgene.

Charge: Bisphenol-A and phosgene.

Product: Thermoplastic resin of about 18,000 molecular weight.

Description: Bisphenol-A, pyridine and solvent are charged into the agitated, jacketed polymerization reactor. Vaporized phosgene is slowly added to the reactor. The reaction which occurs is:



Phosgene and bisphenol react to form polymer molecules with the characteristic carbonate linkage.

The reactor product, including polymer, pyridine hydrochloride and unreacted pyridine in solvent, is washed to remove pyridine hydrochloride. HCl is added to remove unreacted pyridine. More solvent may be added to control viscosity.

The washed product is decanted with pyridine hydrochloride containing phase sent to recovery and polymer solution phase to an agitated precipitation tank. An "antisolvent" is added, forming a solution with the solvent and precipitating the polymer.

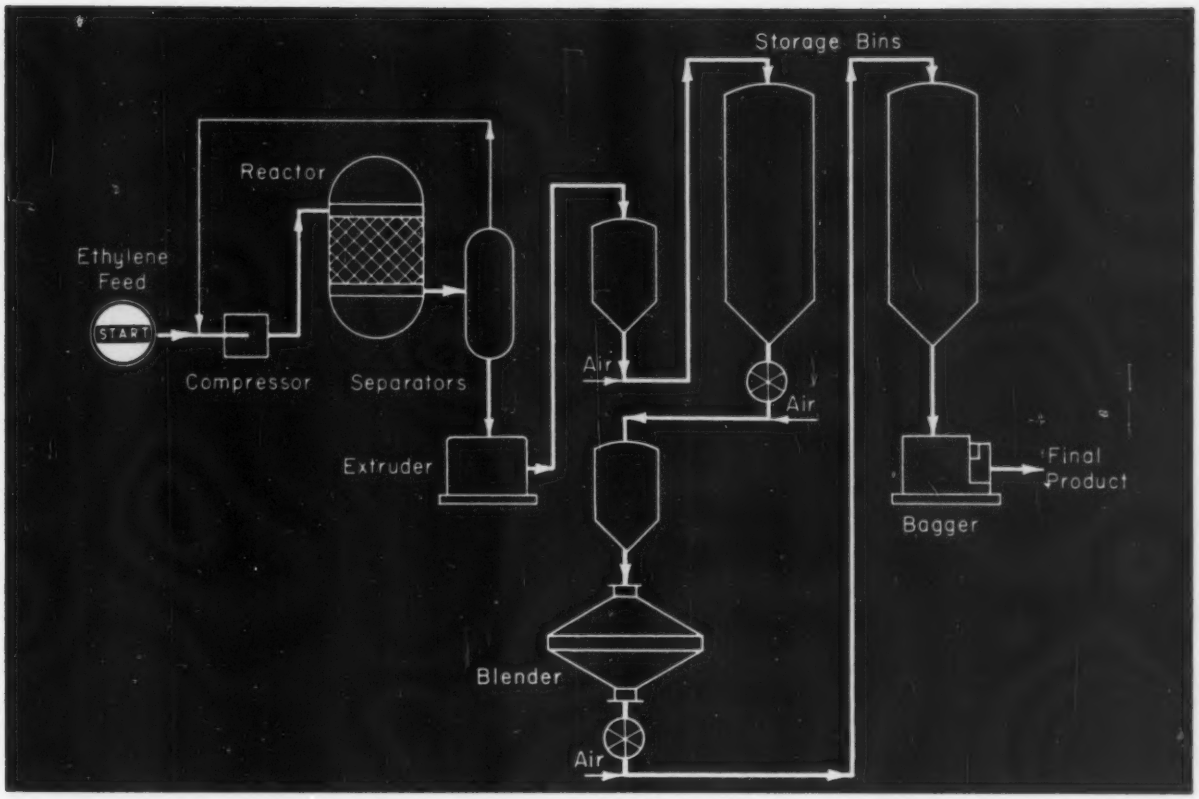
Polycarbonate powder is blended, colored, extruded and pelletized.

Recovery System: Aqueous pyridine hydrochloride is caustic washed, steam stripped to remove solvent and distilled. Pyridine-water azeotrope is taken overhead and salt-solution bottoms discarded. The azeotrope is broken and another distillation step recovers pure, dry pyridine for reuse.

Solvent and antisolvent are separated by distillation, solvent going overhead and antisolvent recovered as bottoms.

Operating Conditions: Product polymer may be controlled by reaction time, temperature and charge proportions. Usually approximately 100° F is maintained from 1-3 hours.

Commercial Installations: General Electric's plant at Mt. Vernon, Ind., has a rated capacity of 5 million pounds per year.



Polyethylene (AGFO)—SCIENTIFIC DESIGN COMPANY, INC.

Application: A process for the manufacture of high pressure polyethylene.

Charge: High-purity ethylene; 99.9 percent preferred.

Product: Pelletized polyethylene, density approximately 0.91-0.93.

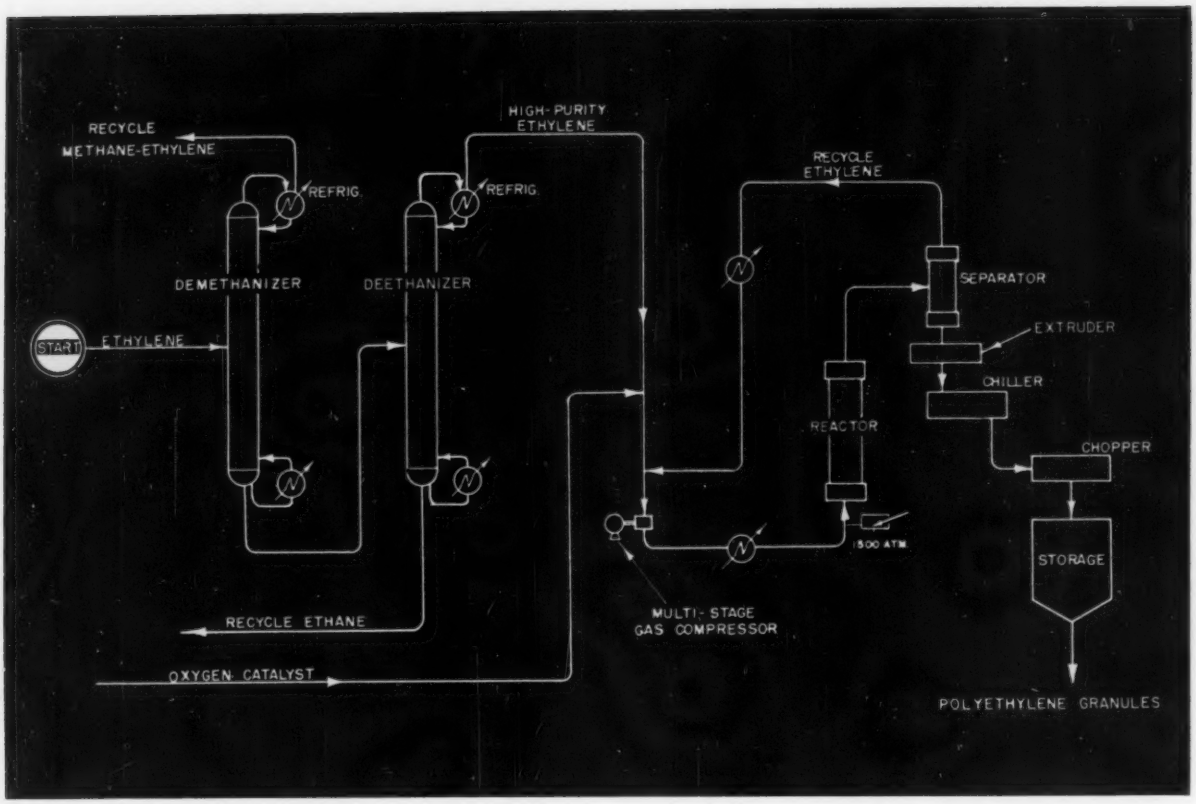
Description: Ethylene feed is mixed with catalyst and with a recycle stream from the polymer separators, then compressed to very high pressure with intermediate and final cooling. This stream is fed continuously to a tubular reactor where careful temperature control is maintained by circulating high pressure water in the jacket. The mixture of ethylene and molten polymer is passed through a separator where the unconverted gas is removed for recycling. To remove from the system the inerts present in the feed, a small bleed stream is taken from the recycle. This is returned to the ethylene purification unit which supplies the feed ethylene.

Molten polymer from the low pressure separator is fed directly to an extruder which lends uniformity to the product. The extruder has a granulating head which reduces the polymer to pellets.

The capacity of a production line is fixed by the characteristics of the process. High capacities are achieved by installing parallel production lines.

The finishing section is very flexible in design and its nature will depend on the desired product distribution. In general, it will include refining extruders, blenders, and storage bins. The polyethylene pellets are transported from one unit to another by means of an air transport system operated by remote control. Coloring facilities may also be included as part of the over-all installation. The product is bagged or shipped directly in special tank cars.

Commercial Installations: Foster Grant Co., Inc., Beaumont, Texas (under construction).



Polyethylene (High Pressure-ICI)

Application: A process for the continuous manufacture of polyethylene.
Charge: Ethylene gas of 90-95 percent purity.
Product: Solid polyethylene.
Description: Polyethylene manufacture requires high purity ethylene and the first step is to purify the ethylene plant product.

The first purification column is the demethanizer in which the overhead, consisting of methane-ethylene, is taken back to the ethylene plant and the bottoms to the second tower where 99.8-99.9 percent ethylene is taken overhead with the bottoms going back to the ethylene plant.

In the *mass polymerization* process, an operating pressure of about 1500 atmospheres and a temperature of about 375° F is used. A free radical yielding catalyst, such as oxygen, is added to the feed and the compressed mixture is fed to the reactor. Once initiated the reaction proceeds quite rapidly with about 25 percent of the ethylene being converted to high molecular weight polymer. Special means are provided to maintain essential isothermal conditions of 375° F.

The effluent from the reactor passes to a separator vessel in which unconverted ethylene is removed and recycled to an intermediate stage of the charge gas compressor. This ethylene contains no oxygen which, though serving as catalyst or initiator, is consumed in the reaction.

The liquid from the separator is water-white polyethylene with a very high viscosity. It is extruded in a form which can be quickly chilled and solidified, such as a continuous ribbon. Final steps in the process are chopping, bin storage, sacking and shipping.

In the *water-solvent polymerization* process, an operating pressure of about 1,000 atmospheres is used. An aromatic hydrocarbon is added as a solvent to improve polymer solubility in the reaction zone and thus permit easier and quicker removal of the formed polymer before it is attacked by growing polymer chains. A mixture of fresh and recycle ethylene, plus about 20 ppm oxygen catalyst, is dissolved in a benzene-water mixture at 375° F. The major constituents in the charge have a weight ratio of about 1.0:1.0:1.5 ethylene:benzene:water. The water contains 100 ppm of oxygen. The charge is fed to a stainless-steel tubular reactor and during the course of reaction additional water is injected to maintain a more constant catalyst concentration throughout the reactor. About 17 percent of the ethylene is converted to polymer. Isothermal conditions of 375° F are maintained. The effluent from the reactor passes to a separator where the unconverted ethylene is removed and recycled as in the mass process. The liquid, consisting of polymer, benzene, and water is sent to a distillation unit where benzene and water are ultimately separated from the heavier polymer.

In the water-solvent process, water carrying additional initiator is injected at multiple points along the reaction tube in order to attain a higher conversion of the ethylene per pass through the reactor. The "half-life" of these initiators normally used is low and consequently it is necessary to continually add initiator to maintain the rate of polymer formation.

The separated polymer is handled as described above for mass-polymerized ethylene.

The product polymer has a molecular weight of 18,000-30,000.

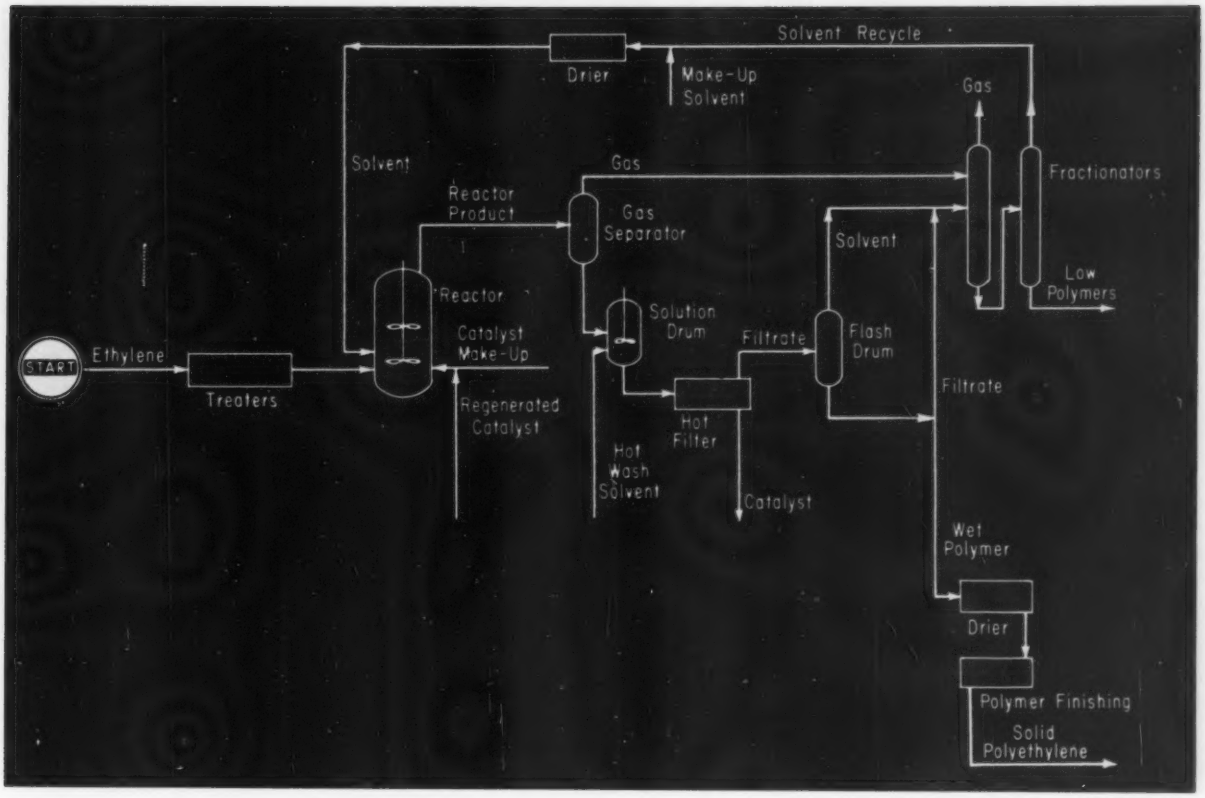
The typical processes described above are subject to variations imposed by the particular properties of polymer desired and the research findings of individual producers. Operating pressures range from 1,000 to 2,000 atmospheres. Autoclave reactors may be used. Free radial generating catalysts which may be used, in addition to oxygen, would include organic peroxides such as benzoyl peroxides and di-tertiary butyl peroxide. Azo compounds and metal alkyls are also effective.

Operating Conditions: Typical values are given above.

Yields: Over-all yield from ethylene is about 95 percent.

Commercial Installations: Union Carbide Chemicals Company, Charleston, W. Va.; Texas City, Texas; Seadrift, Texas; Torrance, Calif., Whiting, Ind. E. I. du Pont de Nemours & Company, Orange, Texas. Canadian Industries, Ltd., Edmonton, Canada. Spencer Chemical Company, Orange, Texas. The Dow Chemical Company, Freeport, Texas. Texas Eastman Company, Longview, Texas. Monsanto Chemical Company, Texas City, Texas. U. S. Industrial Chemicals Co., Tuscola, Ill., Pasadena, Texas, and Koppers Co., Inc., Port Arthur, Texas.

References: "Polyolefin Resin Process," Marshall Sittig, Gulf Publishing Co.



Polyethylene (Low Pressure-Slurry-Solution Process)

Application: A relatively low-pressure process for the continuous production of polyethylene.

Charge: Ethylene gas of 99 percent purity.

Product: Solid polyethylene.

Description: This is a process in which solid catalyst and a solvent are present in the reactor as a slurry, and the polymer is maintained in solution until after the catalyst is removed from the reaction mixture.

The ethylene charge gas, free of sulfur compounds, is treated for removal of catalyst poisons such as water, oxygen and carbon dioxide. Conventional treating may be employed, such as hot metallic copper for oxygen, anhydrous calcium sulfate or alumina for water and supported caustic for carbon dioxide.

The treated ethylene and a suitable hydrocarbon solvent are charged to the reactor at rates to give the equivalent of around 5 weight percent ethylene. A suitable catalyst, such as hexavalent chromium oxide (Cr_2O_3) on a silica-alumina support, is maintained at a concentration of 0.5 percent or less (based on weight of solvent). The solvent may be a C_5 to C_8 paraffin, a naphthene or an aromatic such as toluene or xylene. The aromatics have higher solvency toward polyethylene than the other solvents. The solvent serves several functions in addition to its role as a solvent for ethylene and polyethylene. It protects the growing polymer chain from chain-breakers, controls the viscosity of the solution, controls the rate of ethylene consumption to promote good polymer growth, and it serves as a medium for dissipating the heat of reaction. The reactor is maintained at a temperature of 200° to 300° F and a pressure in the range of 100 to 500 psig.

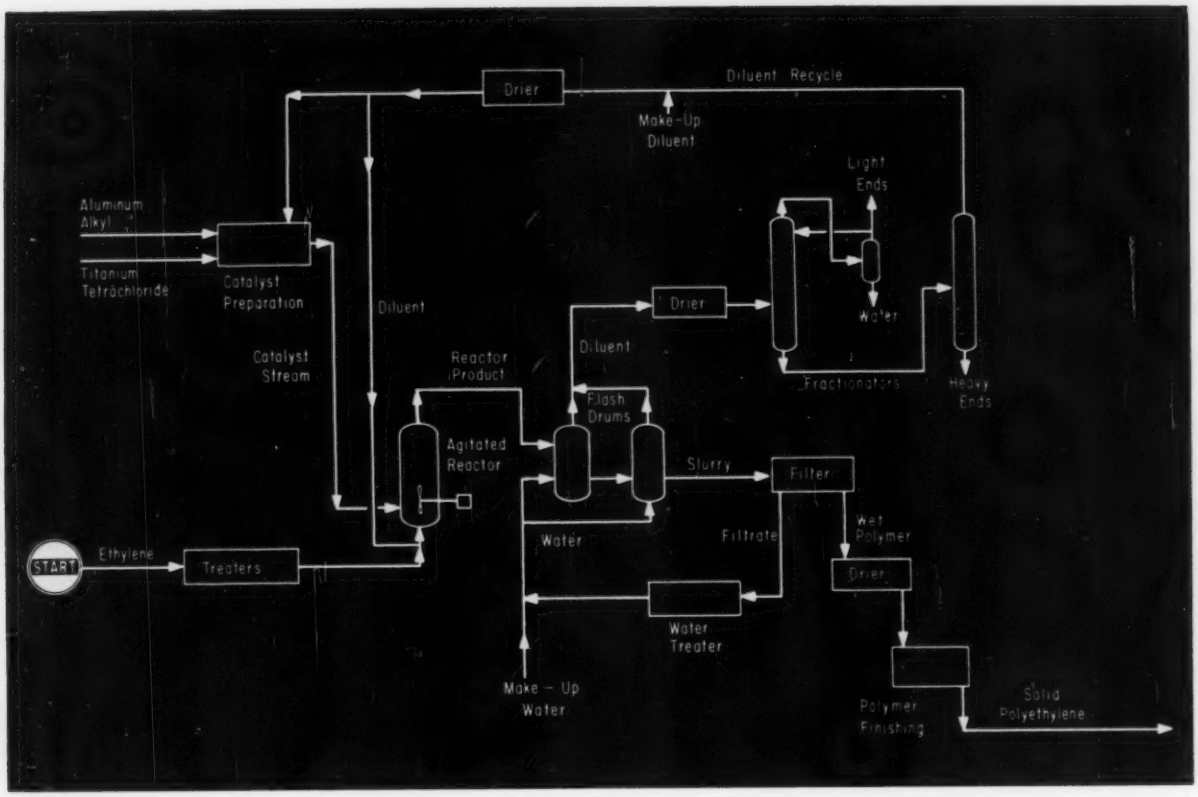
The reactor product is sent to a gas separator and then to a solution drum where additional hot solvent from the deresining operation is added to insure that all of the polymer is in solution. The mixture is then filtered to remove the catalyst which is sent to a deresining chamber where residual polyethylene is recovered from the catalyst. The spent catalyst is regenerated and returned to the reactor.

The hot filtrate is sent to a flash drum for removal of some of the solvent and then to a chiller where the temperature is reduced to 75° to 150° F. The increased polymer concentration and temperature reduction causes the high molecular weight polymer to precipitate and form a slurry. Anti-solvents, such as propane, alcohols or water are usually employed at this step to facilitate separation of the polymer from the solvent. The slurry is filtered to recover an essentially ash-free polymer which is dried and finished as polyethylene pellets. The filtrate and flashed solvent streams are combined and sent to fractionators, along with the separator gas, for solvent recovery and purge of inert gas and low polymers. The solvent is combined with make-up solvent, dried and sent to the reactor.

Operating Conditions: The ranges of the principal operating conditions are given in the foregoing description. They are influenced by the properties of the solvent employed.

Yields: The conversion of ethylene to polymer is virtually 100 percent, and recovery of solid polymer is in excess of 98 percent.

Commercial Installations: The following plants utilize variations of the process principles described here: Celanese Corp. of America, Pasadena, Texas; W. R. Grace and Co., Baton Rouge, La.; Phillips Chemical Co., Pasadena, Texas, and Union Carbide Chemicals Co., Seadrift, Texas.



Polyethylene and Polypropylene (Low Pressure-Ziegler)

Application: A low pressure process for the continuous production of polyethylene (or polypropylene).

Charge: Ethylene gas of 99 percent purity for polyethylene. (Propylene of similar purity for polypropylene.)

Product: Solid polyethylene (or polypropylene).

Description: The accompanying flowsheet describes the principles of the low pressure polyethylene process that employs Ziegler catalysts. Many details of the process are still confidential, especially those related to catalyst preparation and to catalyst and ash removal after the polymer is formed. Numerous catalyst combinations are possible; however, the popular combination consists of aluminum triethyl, which promotes the polymerization, and titanium tetrachloride, which in combination with aluminum triethyl forms a finely divided precipitate which catalyzes the anionic polymerization. The catalyst constituents are extremely reactive to water and oxygen; therefore, since only a trace of catalyst is required, it is carried in a carefully dried diluent under conditions that make it safe to handle.

The ethylene charge gas is treated for removal of sulfur compounds, oxygen, water and carbon dioxide, and is then charged to the reactor. The diluent may be a C_5 to C_7 paraffin or naphthene or one of the lower aromatics. The catalyst is charged as a very dilute stream. The reactor is maintained at a pressure in the range of one atmosphere to 100 psig and a temperature of 140° to 170° F.

The reactor product is sent to a series of flash drums to remove the diluent. These drums are maintained at conditions in the range of 3 to 5 psig and the appropriate temperature to flash the diluent. Water is added to the flash drums to destroy the catalyst and slurry the polymer. The diluent is sent to a drier to remove entrained water and then charged to a fractionator where light ends and water are removed as an azetrope. The bottoms is sent to a second fractionator for removal of heavy ends, and the diluent is recovered for recycle.

The water-polyethylene slurry is filtered, and the aqueous filtrate is treated and recycled to the flash drums. Alcohol may be used in place of water to destroy the catalyst and wash it from the polymer. Additional filtration steps and special treating agents may be employed to help remove the catalyst. The solid polyethylene is dried, extruded and finished to form polyethylene pellets. Higher boiling diluents may be used. In this case a different diluent recovery system would be required.

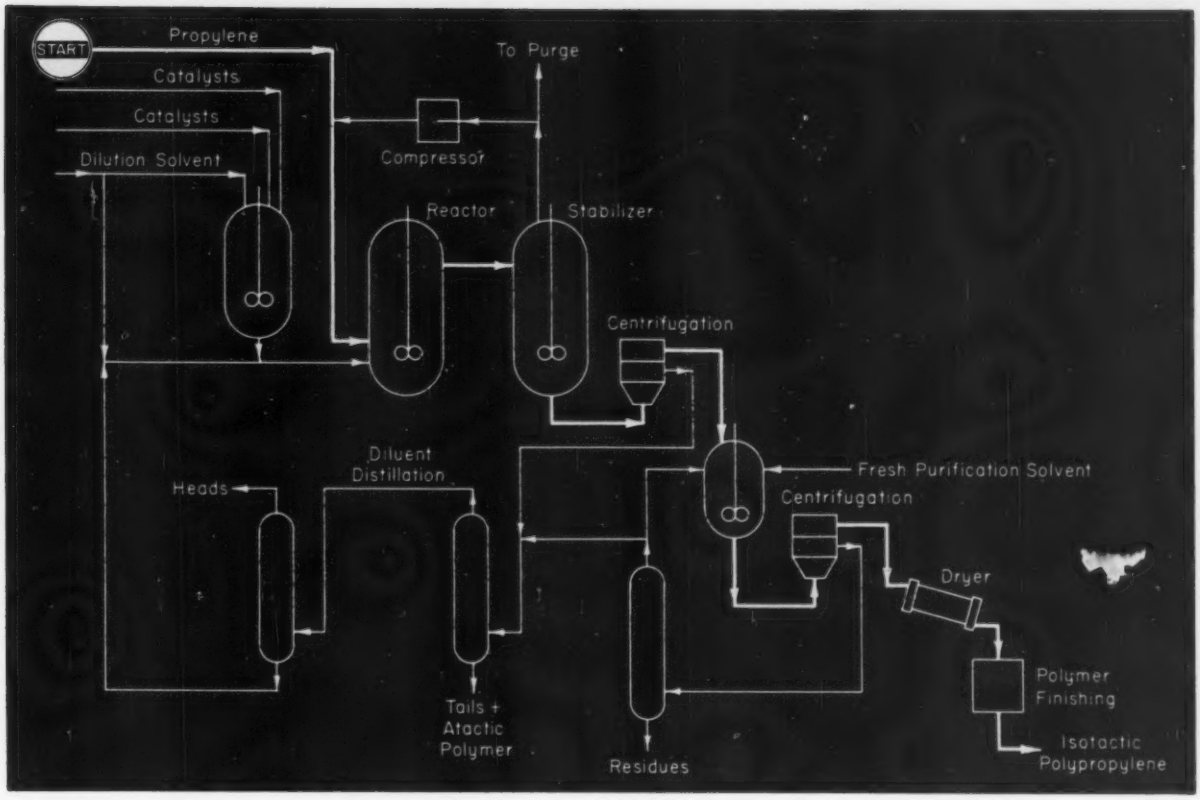
Operating Conditions: The operating conditions given above are influenced by the physical properties of the diluent.

Yields: The over-all yield of polymer is around 95-98 percent of the ethylene consumed.

Polypropylene: This polymer is made from propylene in essentially the same process and under nearly the same conditions except that titanium trichloride is used in place of titanium tetrachloride. This increases the yield of polymer to over 90 percent based on the olefin charged.

Commercial Installations: *Ziegler Polyethylene:* Dow Chemical Co., Bay City, Mich.; Hercules Powder Co., Parlin, N. J.; Koppers Chemical Co., Port Reading, N. J.; and Union Carbide Chemicals Co., Institute, W. Va.

Polypropylene: Hercules Powder Co., Parlin, N. J.



Polypropylene — MONTECATINI

Application: A continuous process for manufacturing isotactic polypropylene, by low pressure stereospecific polymerization of propylene.

Charge: Propylene "polymerization grade" 99 percent pure. Solvents. Catalysts.

Product: Solid isotactic polypropylene in pellets.

Description: Polypropylene is produced by means of catalytic polymerization in the presence of catalysts obtained by reaction of metallorganic compounds, particularly aluminum-alkyls, with titanium halides.

The propylene monomer used is highly concentrated and processed so as to reduce to allowable values the content of impurities which can negatively influence the catalyst activity.

The catalyst components are reacted in a hydrocarbon medium and the resulting complex is fed to the reactor.

Paraffinic hydrocarbons, such as C_6^+, C_7^+ are generally used as reaction diluent substances.

The reactor works at a pressure of 1 to 10 atm. and it is thermostatized in order to maintain the temperature in the range from 50 to 100° C.

All reagents are fed continuously to the reactor and the reaction product is also continuously transferred as a suspension to a stabilizer where unconverted monomer is flashed and recycled to the reactor after a suitable purge in order to keep the amount of inert gases within an acceptable value.

The stabilized reaction suspension is centrifuged and washed with a proper mixture of organic solvents with the purpose of removing the greatest part of the reaction diluent and of deactivating and consequently eliminating the residual catalyst.

The diluent used in the reaction and depration steps are then recycled, after having been suitably purified by means of distillation.

The polymer coming from a second centrifugation step is dried, stabilized, extruded and finally hot granulated in lens-shape.

Operating Conditions: The above mentioned operating conditions have only a pure indicative value. They may be changed depending on the characteristics wanted in the final product.

Product Characteristics: Average characteristics of a polymer obtained by the outlined process are as follows:

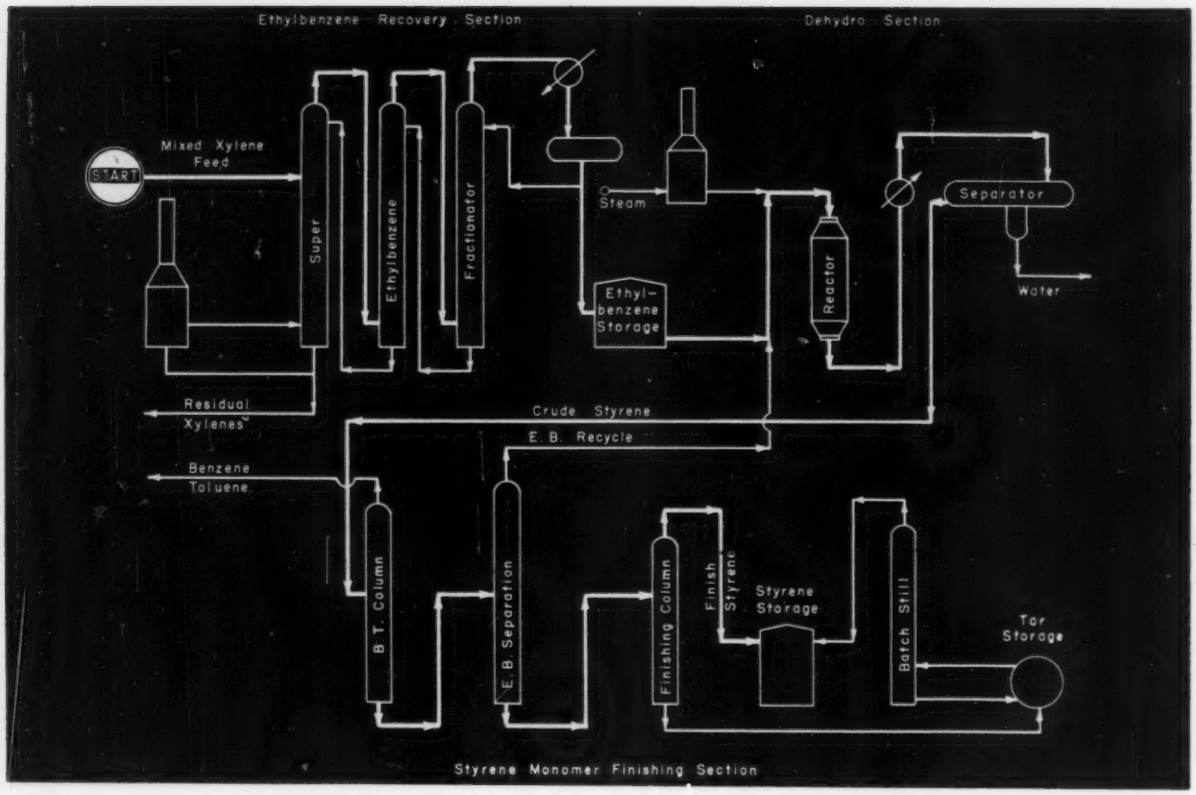
isotactic index	90 —	98	
tensile strength	3,250 —	4,800	psi
ultimate elongation	300 —	600	%
flexing stiffness (flexural elastic modulus)	14,000 —	10,000	psi
Vicat softening point (1 kg)	302		F°
distortion temperature (ASTM-66 psi)	212 —	266	F°
Rockwell hardness	60 —	65	L scale
ashes	<0.05		%
dielectric constant (18 MHz)	2 —	2.2	
dissipation factor (18 MHz)	0.0003 —	0.0010	
dielectric stiffness (rigidity) short time test	32		KV/mm

Commercial Installations: Polypropylene is now produced, by the above mentioned continuous process, at Montecatini Factory in Ferrara (Italy) and at Danubia Factory in Schwechat (Vienna).

A Montecatini plant using the same process is going to operate at Neal (West Virginia U.S.A.) under the name of Novamont Corp.

Other Montecatini plants for polypropylene production are under construction in the new petrochemical factory at Brindisi (Italy).

The process has been licensed to Imperial Chemical Industries and Shell Co. in Great Britain; to Rotterdamse Polyolefinen Maatshappij in Netherland; to Esso Svenska Co. in Scandinavian Countries and to Mitsui, Mitsubishi and Sumitomo in Japan for polypropylene production.



Styrene— COSDEN PETROLEUM CORPORATION

Application: Process for manufacturing styrene monomer by recovery of ethylbenzene in petroleum stocks.

Charge: Mixed xylenes from aromatic purification unit.

Product: Plastic or rubber grade styrene monomer.

Color	10 Max.	(APHA)
Assay		99.6% Min.
Polymer		Nil
Sulfur		0.003% Max.
Aldehydes		0.02% Max.
Peroxides		0.01% Max.

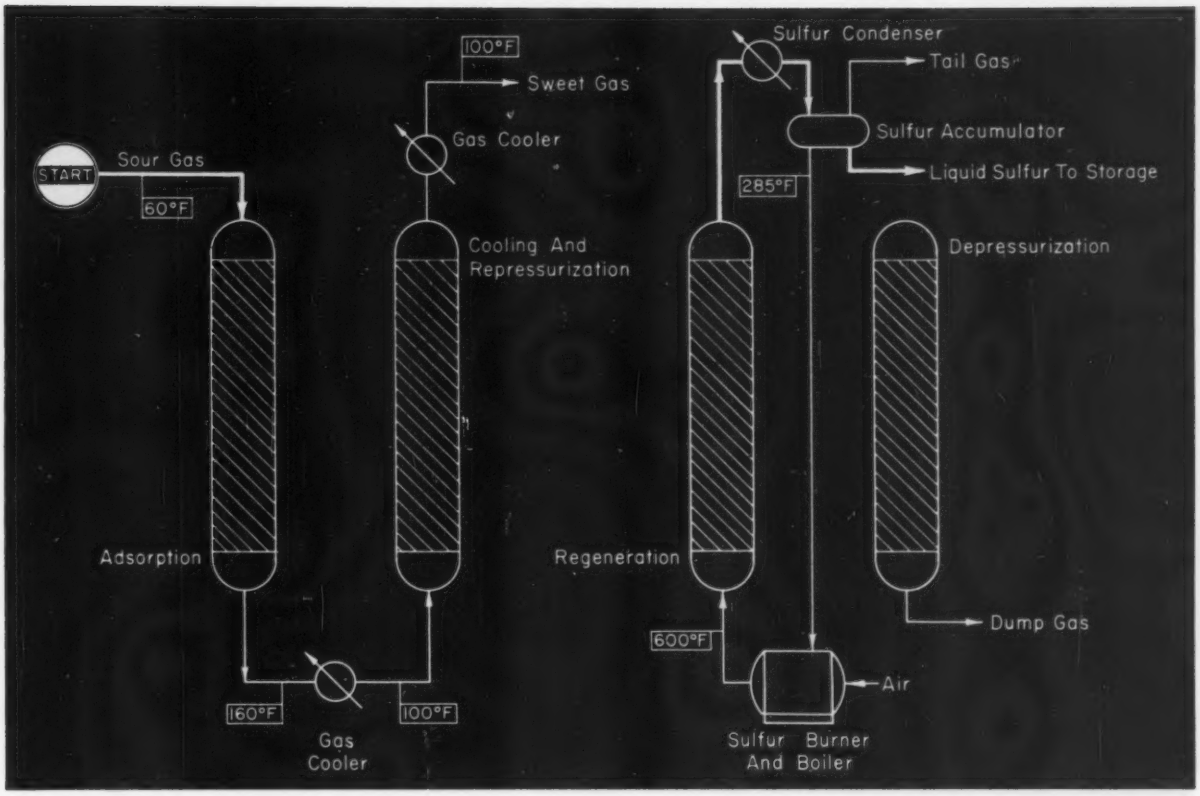
Description: The feed stock to the super fractionating column is mixed xylene isomers containing essentially no non-aromatic hydrocarbons boiling in the xylene range. In this column, ethylbenzene which boils at 3.9° F lower than its nearest xylene isomer, (paraxylene), is separated in sufficient purity to make at least 99.6 percent styrene monomer. To affect this separation, three 200-foot columns are used in series and operated at high reflux rates. The ethylbenzene product from the recovery section has to be maintained essentially free from any other hydrocarbons boiling in the range of ethylbenzene and styrene monomer as purity produced here will govern the maximum purity of finished styrene monomer.

Fresh ethylbenzene is combined with recycle and charged to the dehydrogenation reactor after mixing with super heated steam. The dehydrogenation takes place at low pressure and a high mole ratio of steam to ethylbenzene is maintained. The reactor effluent is condensed and collected in a separator where the steam condensate is withdrawn. Reactor pressure and temperature are major control points for maintaining conversion in the optimum range of 35 to 40 percent per pass. Ethylbenzene conversion to styrene monomer will approximate 90 weight percent.

In the styrene monomer finishing section, the small amount of benzene and toluene produced by cracking in the reactor is first removed by fractionation in a small vacuum column. In the next column, ethylbenzene, for recycle back to the reactor, is separated from the styrene. This separation is accomplished in one column operating at an extremely low pressure. This effects substantial savings in investment and operating cost over the conventional two-column system. Inhibitors are added and high temperatures avoided in order to minimize polymer formation. Another small column is required to separate the finished styrene monomer from small amounts of tar and polymer formed during the operation. The tars and polymers are collected in a batch pot and periodically the remaining monomer in this material is recovered.

Very high recovery of ethylbenzene is realized by this process. It avoids the corrosion and purification problems associated with aluminum chloride alkylation of benzene and ethylene. Furthermore, no impurities of the type normally found in synthetic ethylbenzene are present which produce unstable monomers that complicate styrene monomer recovery and finishing operations. The entire unit is essentially free of corrosion and fouling problems and can be operated for long periods without downtime.

Reference: Industrial & Engineering Chemistry, Vol. 52, July 1960 p 550.



Sulfur Recovery (Haines Process)— KRELL AND ASSOCIATES, INCORPORATED

Application: A process for the desulfurization of natural gas.
Charge: Sour natural gas.
Product: Sulfur of 99.9 percent purity.
Description of Process: Hydrogen sulfide is removed from the raw gas stream by adsorption on synthetic crystalline zeolities. The adsorbent, which also functions as a Claus catalyst, is then regenerated with hot sulfur-burner gases for production of elemental sulfur:

$$H_2S + \tfrac{1}{2}\,SO_2 = H_2O + \tfrac{3}{2}\,S$$

Sulfur-burner gases, in turn, are generated by combusting a portion of the condensed sulfur output. Normally, the process is carried out continuously in a four-tower system.

Raw gas is fed downward through the adsorption tower; sweet gas leaving this tower will contain considerably less than ¼ grain of hydrogen sulfide per 100 standard cubic feet. At the conclusion of the adsorption period the flow of raw gas is automatically switched to a second tower containing synthetic crystalline zeolites, which, after regeneration, has previously been cooled by series flow of the sweet gas or by closed-cycle vaporization of a liquid hydrocarbon.

During the adsorption period, the third tower in the system is being regenerated upflow with hot sulfur-burner gases at essentially atmospheric pressure. Sulfur vapor leaving the tower is condensed by a water-cooled or air-cooled condenser; a portion of the liquid make is recycled to the sulfur burner for production of the sulfur dioxide containing regeneration gas.

Prior to regeneration, the fourth tower is depressurized. "Dump" gas from this tower may be fed to the plant stack for incineration of unconverted hydrogen sulfide in the tail gas, or to the air intake of the sulfur burner for production of additional sulfur dioxide. After regeneration and prior to cooling, the second tower is purged and repressurized with a bleed stream of raw gas.

When low pressure gases are to be purified, the fourth tower may be omitted from the system. In situations where the raw gas contains very low concentrations of hydrogen sulfide, such that the daily sulfur production does not justify operation of a sulfur burner, the system may be regenerated with air:

$$H_2S + 3/2\;0_2 = H_2O + SO_2$$

This type of desulfurization plant does not manufacture elemental sulfur and sulfur dioxide must be vented to the atmosphere.

Operating Conditions: When gases containing high concentrations of hydrogen sulfide are processed the heat of adsorption may cause a temperature rise of 100° F across the adsorption tower. Hence, a cooler is provided for lowering the temperature of the sweet gas flowing to the cooling tower.

Sulfur-burner gases enter the regeneration tower above the sulfur dew point (500 to 550° F) and the product gases leave at substantially the same temperature. Liquid sulfur is condensed from these gases at 285 to 300° F.

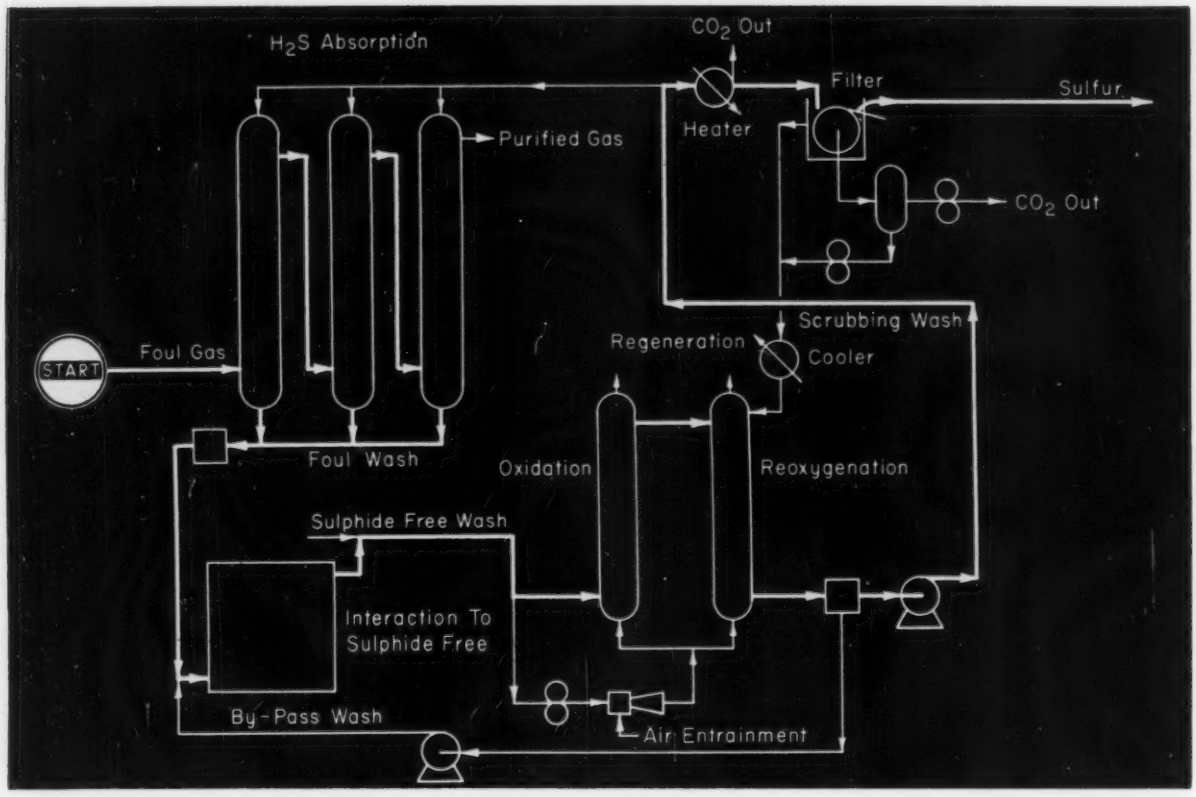
Depending upon inlet hydrogen sulfide concentrations, the adsorption period may vary from about 30 minutes to 1½ hours. Under normal operating conditions, mass velocities of gases flowing through the system will fall in the range of 800 to 8,000 pounds per hour per square foot.

Yields: Sulfur yields of 85 to 88 percent may be obtained in a single-stage unit, based on hydrogen sulfide fed to the adsorption tower. Where higher recoveries are required (up to 95 percent) a conventional Claus catalyst chamber may be placed offsite in series with the tail gas leaving the sulfur accumulator.

Commercial Installations: Bench-scale tests have been concluded and a semi-works pilot plant is under construction in Alberta, Canada.

References: PETROLEUM REFINER, Vol. 40, No. 4, April 1961 pp. 123; The Oil and Gas Journal, May 22, 1961, pp. 78.

Licensor: United States—Sulfur Recovery, Inc.; Canada—Western Sulfur Recovery Ltd.; Foreign—Krell & Associates, Inc.



Sulfur Recovery (Stretford Process) — THE CLAYTON ANILINE COMPANY, LTD.

Application: A continuous liquid oxidation process for the removal of hydrogen sulfide from gaseous mixtures and liquid hydrocarbons.

Principle: The gaseous mixture is washed with an aqueous alkaline solution of anthraquinone disulfonic acids which react with the SH^- ion, giving an intermediate compound which, in the presence of oxygen, liberates sulfur and is itself oxidised back to its original state. The process can be accelerated by the addition of vanadates.

End-product: Gaseous mixtures with a hydrogen sulfide content of less than 1 p.p.m. and sulfur of saleable quality.

Description: Gaseous mixtures containing hydrogen sulfide are scrubbed continuously in counter-current flow in packed towers, the gas being fed through the towers in series flow while the washing medium passes down the towers in parallel flow. The number and size of towers required depends on the volume of gas to be treated, concentration of hydrogen sulfide in the gas, and the degree of removal required.

The washing solution from the scrubbing towers is passed through a reaction tank where the SH ion in solution reacts with the anthraquinone disulfonic acid and dissolved oxygen, resulting in the precipitation of sulfur.

The washing solution, which is then substantially free of SH ion, is passed to an oxidiser, preferably in co-current flow with a stream of air, whereby the reduced form of anthraquinone disulfonic acid is oxidised to its original state and the washing solution is reoxygenated.

The whole or a portion of the washing solution is passed through a filtration system for sulfur removal. The sulfur so obtained can be directly dried to a product of 95 percent purity, or if suitably treated to yield sulfur of 99.9 percent purity. The washing solution is then returned after filtration to the scrubbing towers.

The washing solution is generally buffered in the required pH range of 8.5 to 9.5 with sodium carbonate/bicarbonate and when the gas being scrubbed contains carbon dioxide, some form of decarbonification is necessary to prevent reduction of the pH value below optimum range. This is achieved by by-passing a portion of the washing liquor, after oxidation, through a heating chamber where carbon dioxide is expelled.

The addition of vanadates to the anthraquinone disulfonic acid solution has the following advantages:

1. Increase in speed of reaction, resulting in the use of smaller amounts of washing liquor and therefore a decrease in capital outlay for the plant.
2. The lower pH, 8.0 to 8.5, at which the Vanadate/anthraquinone disulfonic acid process operates, obviates the necessity for decarbonification thus reducing operational costs.
3. Side reactions, e.g. formation of thiosulfate, are reduced.

The process can be carried out at, or above, atmospheric pressure and requires very little supervision.

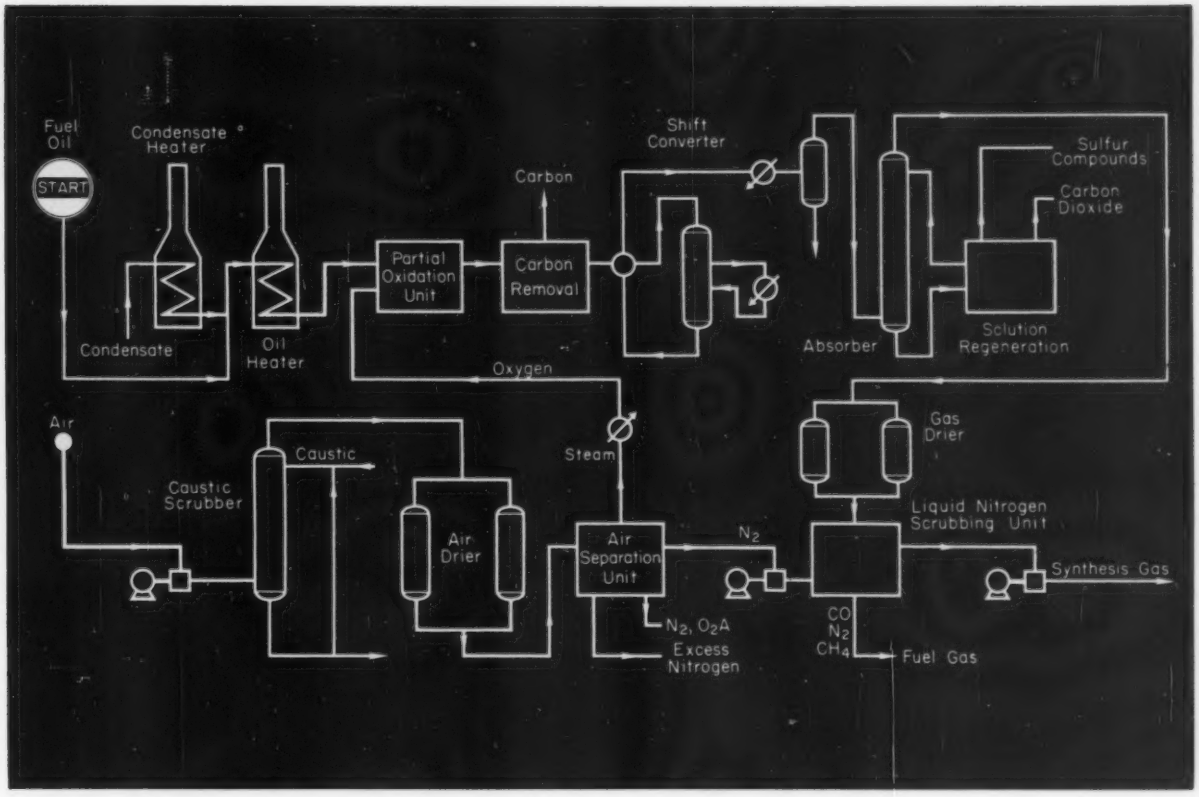
Further advantages over known liquid purification processes are:

a) The stability of the reactants to conditions other than process requirements.
b) The ability to limit side reactions, e.g. thiosulfate formation, to 2-3 percent of the sulfur input thus ensuring long life of the initial charge.
c) Sulfur can be recovered in a high state of purity.
d) Low power costs for operation.

Commercial Installations: The North Western Gas Board have successfully operated a small scale plant, purifying coal gas, at Whitchurch, Shropshire for two years and a large scale plant at Linacre Gas Works, Liverpool, for 10 months. The South Western Gas Board have also operated a large scale plant at Bristol for eight months.

Orders for further installations, both in Great Britain and on the Continent, have been received and these are now under construction.

The licencees of the process are: W. C. Holmes & Co. Ltd., Newton Chambers & Co. Ltd., R. & J. Dempster Ltd., Simon-Carves Ltd., Humphreys & Glasgow Ltd., and Woodall-Duckham Construction Co. Ltd.



Synthesis Gas (Fuel Oil)—THE FLUOR CORPORATION, LTD.

Application: A process for the manufacture of nitrogen hydrogen mixture or hydrogen.

Charge: Air and fuel oil.

Product: Hydrogen or synthesis gas containing 75 percent hydrogen and 25 percent nitrogen.

Description: Briefly, the process indicated consists of the following steps: (1) Separation of air into nitrogen and oxygen; (2) controlled partial oxidation of fuel oil to produce hydrogen; (3) purification of the hydrogen to remove unconverted carbon, sulfur compounds, carbon dioxide, and carbon monoxide. If snythesis gas is desired, methane, argon, and residual carbon monoxide are removed in a nitrogen scrubbing unit.

As indicated in the simplified flow diagram, air is compressed, scrubbed with caustic to remove carbon dioxide, dried, and separated in a low temperature air separation unit (A.S.U.) into nitrogen of 99.99 percent purity, oxygen of 85 percent or better purity, and a stream containing nitrogen, oxygen, and argon. When producing sufficient oxygen for the partial oxidation reaction, excess pure nitrogen will be produced over that required for ammonia. A controlled quantity of oxygen is fed with preheated oil-steam mixture to the partial oxidation unit, where a series of reactions take place yielding hydrogen, carbon monoxide and small quantities of carbon dioxide and methane. After removal of traces of unconverted carbon, the gas is fed to a shift converter, where the carbon monoxide reacts with steam to form carbon dioxide and hydrogen. The effluent is cooled in a series of heat exchangers and coolers and fed into a contactor for removal of carbon dioxide. For this step, monoethanolamine, hot potassium carbonate, Giammarco-Vetrocoke, or Fluor Solvent Process may be used.

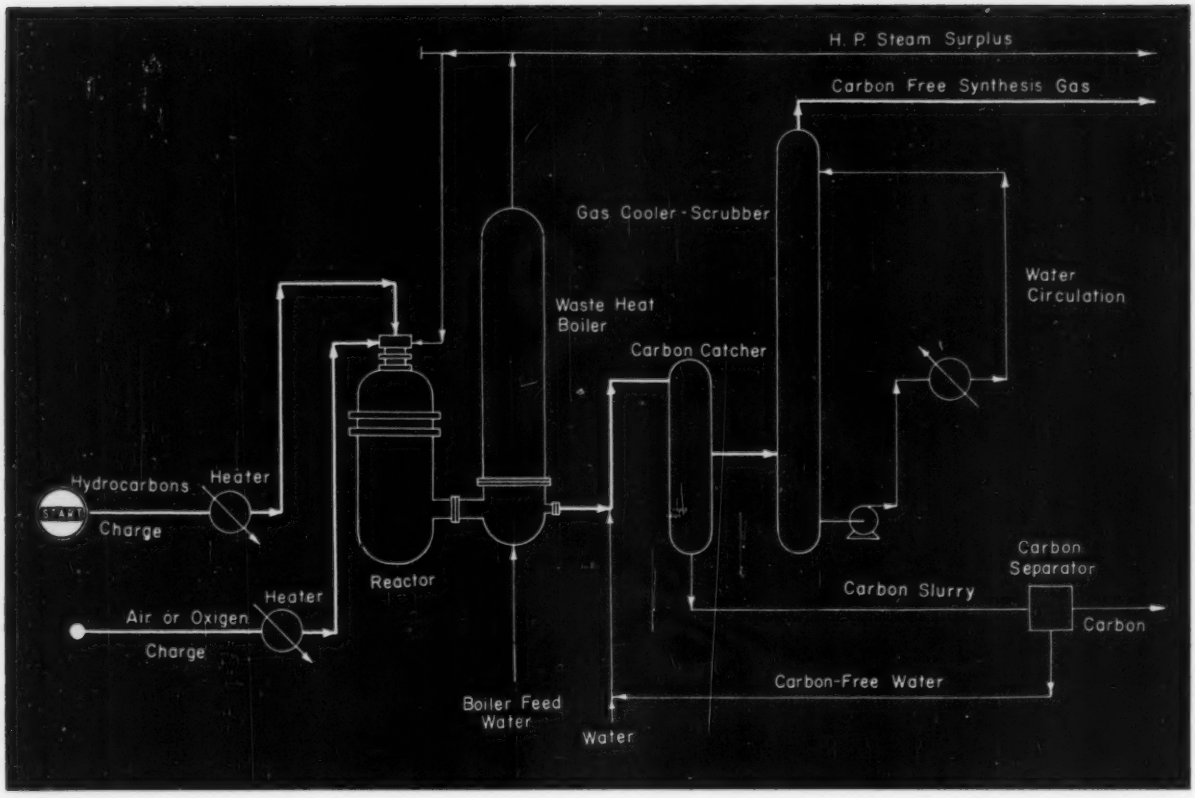
The hydrogen containing traces of carbon dioxide, argon, carbon monoxide, and some methane is then dehydrated and fed into a low temperature nitrogen scrubbing unit (N.S.U.) where these remaining impurities are scrubbed out the bottom as a low Btu value fuel gas (350-500 Btu/CF). The gas leaving the top of the tower contains about 80 percent hydrogen and is easily adjusted to 75 percent hydrogen by introduction of a controlled amount of pure nitrogen. The adjusted mixture of pure synthesis gas flows to the synthesis gas compressors for compression to about 200-600 atmospheres. The gas to the N.S.U. is fairly pure hydrogen and is suitable for hydrogen treating of petroleum stocks. In this case the N.S.U. is omitted. If the sulfur content of the feed is very high, the processing scheme is slightly modified to remove sulfur compounds from the gas prior to shift conversion. The solution stripping operation can also be arranged to produce pure carbon dioxide if this is desired for other uses.

Operating Conditions: The partial oxidation unit is non-catalytic and operates at about 2600° F and 25-30 atmospheres.

Yield: 91 to 92 percent hydrogen on the basis of oil feed.

Commercial Installations: There are several commercial installations of the partial oxidation gas generation process using fuel oil as raw material. Variations of this process are being used at Northern Chemical Industries Inc., Searsport, Maine; Gonzales Chemicals Industries Inc., Guanica, Puerto Rico; Canadian Industries Ltd., Millhaven, Ontario; Republic of Korea, Chung Ju, Korea; and Asahi Chemical Industries Co., Ltd., Nokeahu, Japan.

References: PETROLEUM REFINER, Dec.'54,p156,May'55,p145.



Synthesis Gas— SHELL DEVELOPMENT COMPANY

Application: Continuous, non-catalytic conversion of any hydrocarbon into fuel, synthesis, or ore-reduction gas by means of controlled partial combustion in a special reactor.

Description: In the basic form of the Shell Gasification Process, oil and oxidant (oxygen or air) are separately preheated and charged to the reactor. Before entering the reaction zone, they are intimately mixed in a combustion chamber. The heat produced by combustion of part of the oil pyrolyzes the remaining oil into gas and a small amount of carbon in the reaction zone. The reactor effluent then passes through a Shell-patented waste-heat boiler, a carbon removal unit, and a water cooler-scrubber. These steps provide advantages of a) high pressure steam generation for use outside plot limits and b) a virtually carbon-free gas (<1 ppm). The carbon is recovered in equipment of simple design in a form which can be used as fuel or in ordinary carbon products.

Operation: The process is continuous, simple to operate, and requires minimum labor and supervision. On-stream factors of 95 percent have been achieved. Practically the entire plant is constructed of carbon steel. Commercial-grade firebrick is used as refractory in the reactor section. Experience in existing plants has revealed no maintenance problems.

The high flexibility of the process makes it possible to change feedstock within a half hour, and the plant thruput can be reduced to about 60 percent of design capacity without any effect on the equipment or on the performance of the process.

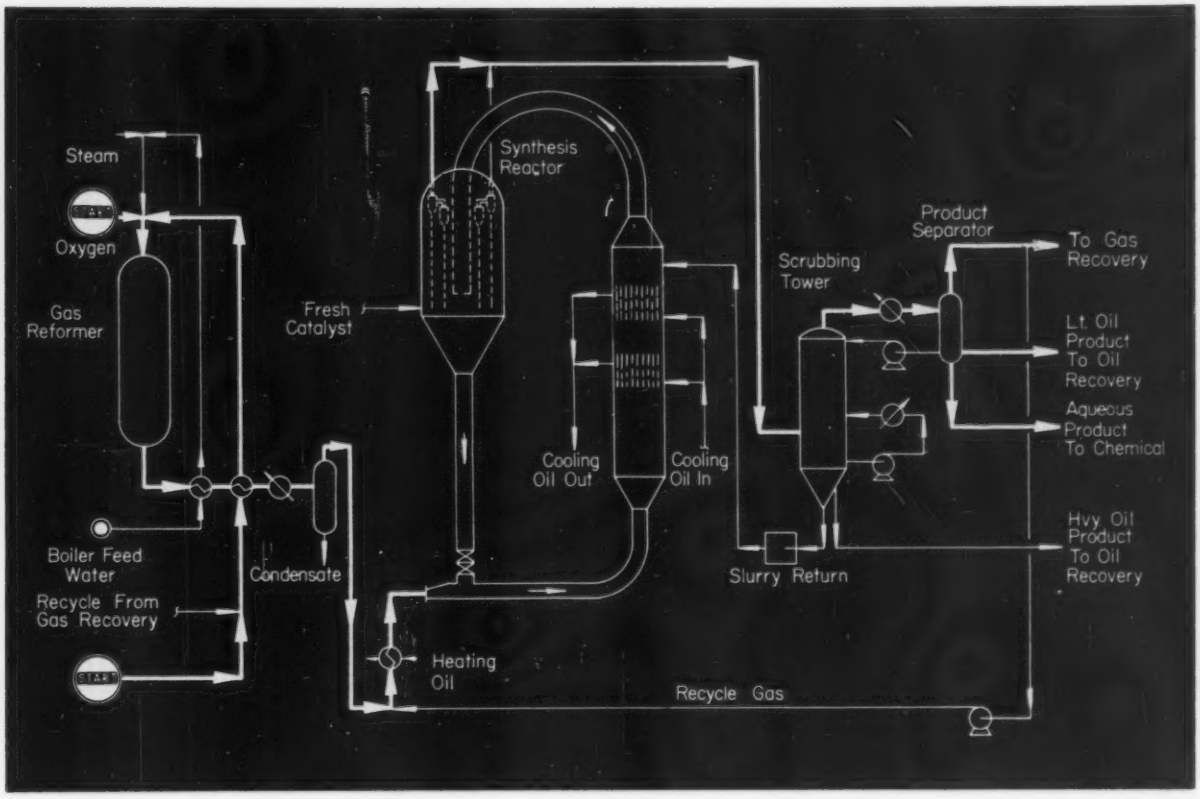
Yields: Typical results obtained by application of the process for production of synthesis gas are shown in the following table:

Unit: Volume Percent of Crude, Dry Product

Product Components	Feedstocks: Natural Gas	Naphtha	Heavy Fuel Oil
H_2	60.9	51.6	46.1
CO	34.5	41.8	46.9
CO_2	2.8	4.8	4.3
CH_4	0.4	0.4	0.4
$N_2 + A$	1.4	1.4	1.4
$H_2S + COS$	—	70 ppm	0.9

Commercial Installations: 8 plants now operating; 7 under construction.

Reference: PETROLEUM REFINER, **39,** 151 (March, 1960), Erdoel u. Kohl, **12,** 959 (December, 1959), Chemical Engineering Progress **59,** 68 (July 1961).



Synthol Process— THE M. W. KELLOGG COMPANY

Application: A process for the synthesis of hydrocarbons and oxygenated chemicals from hydrogen and carbon monoxide.

Charge: Purified synthesis gas having a hydrogen to carbon monoxide ratio of 2.0 to 3.2.

Product: High olefin content hydrocarbons within the boiling point range of gasoline through heavy fuel oil as well as a wide range of oxygenated chemicals. The following is typical of the products produced from one type of recovery: LPG (50-100 psia vapor pressure), motor gasoline (85-90 CFRR clear), diesel oil, fuel oil, methanol, ethanol, methyl ethyl ketone, and acetone. Both water soluble and oil soluble organic acids may also be recovered.

Description: The feed gas is a mixture of hydrogen, carbon monoxide and carbon dioxide plus light hydrocarbons. This gas should be treated for the removal of sulfur compounds and resins if present. The purified feed enters the gas reforming unit where it is mixed with recycle tail gas from the recovery units and preheated by suitable heat exchange with the reformer effluent. Steam is then added to this mixture and the total stream is fed to the reforming chamber where it is mixed with essentially pure oxygen. Partial oxidation and reforming of the gas takes place over the catalyst in the reformer chamber at temperatures in the range of 1,600°-2,200° F and pressures in the order of 350 psig. The gases are then heat exchanged to generate almost all of the steam required for the feed and further exchanged and cooled to remove the water vapor. The reformed gas consists primarily of hydrogen and carbon monoxide and is fed to the Synthol unit.

The synthesis is carried out over an iron catalyst in a single stage powdered catalyst reaction system. The basic synthesis reaction is the hydrogenation of CO to yield hydrocarbons and water. Side reactions produce oxygenated compound also.

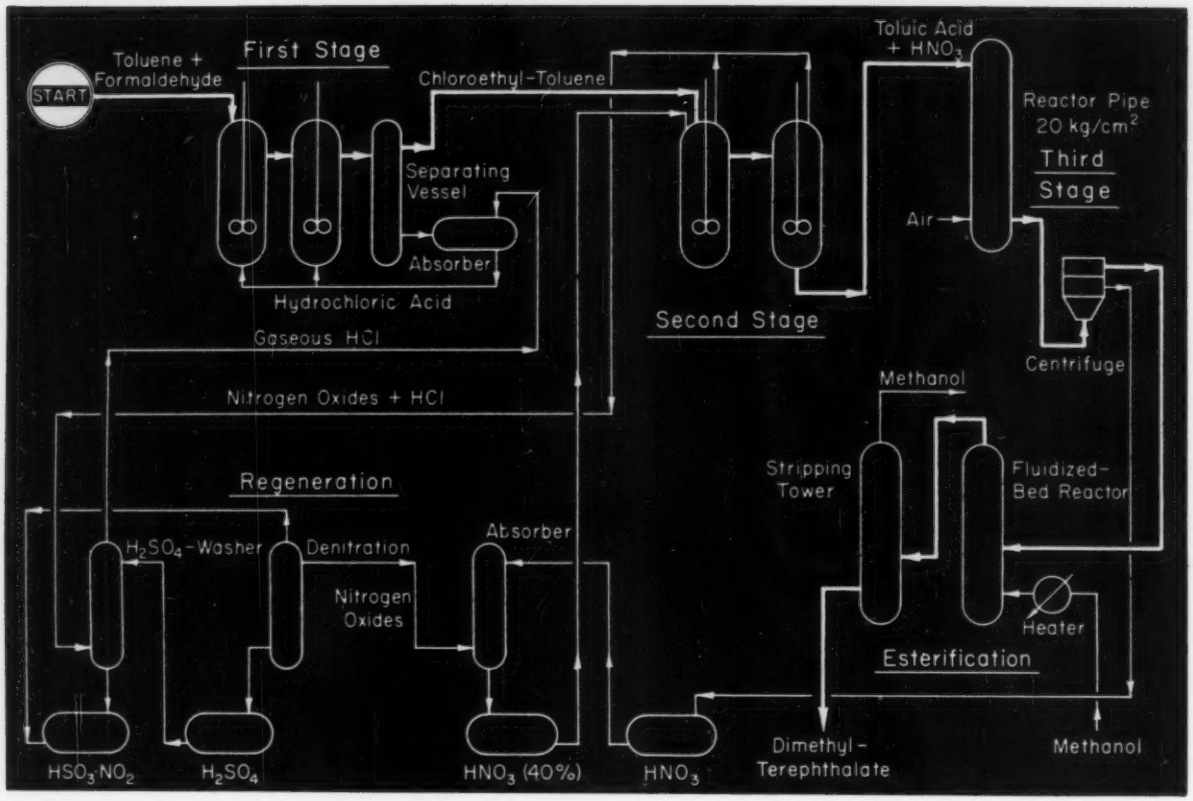
The synthesis gas coming from the reforming section is preheated and mixed with recycle gas before entering the reactor. Catalyst and gas mix in the transfer line and flow to the reaction zone. This transfer line velocity is 25-35 fps. The reactor operates with a gas velocity of 4-7 fps, temperature range of 590°-650° F, and pressure range of 250-350 psig. The catalyst-gas mixture moves through the reactor-cooler sections and into the settling zone. Here most of the catalyst disengages and recirculates down through the standpipe and slide valves. Cyclones installed in the settling zone remove most of the entrained fines.

Reactor effluent gas is quenched in a scrubbing tower where the remaining catalyst dust is removed. This fine catalyst is returned to the reaction zone in the form of a heavy oil slurry. A heavy oil product is removed from the bottom of the tower, and the other oil and chemical products pass overhead. The heat removal is by intermediate and top tower reflux. The overhead is cooled and condensed to yield the light oil and aqueous product liquids and the gas product, which is divided into recycle and net gas product.

The gas product passes on to recovery where the hydrocarbons are removed for conversion to polymer gasoline. The light and heavy oil products are processed to produce gasoline and the other products mentioned above. The aqueous product is processed for recovery of the pure chemicals noted above.

Yields: Conversions of carbon monoxide in the synthesis reactor are 95 percent-98 percent. Over-all carbon utilization from purified feed gas to useful products can be maintained at about 88 percent through recycle of unconverted gases regardless of conversion level. If the carbon dioxide, which must be scrubbed from the gas returning to the reforming unit can be utilized, this over-all figure is several percent higher.

Commercial Installations: This process is being employed in the South African Coal, Oil and Gas Corp. plant in the Union of South Africa.



Terephthalic Acid— BERGBAU-FORSCHUNG

Application: A process for producing benzene carboxylic acids using toluene for terephthalic acid and xylene for pyromellitic acid.

Charge: Toluene, xylene, formaldehyde, HCl and nitric acid.

Products: Terephthalic acid, pyromellitic acid, phthalic acid and other carboxylic acids depending on charge materials and extent of processing.

Description: For the manufacture of terephthalic acid the process proceeds as follows:

First Stage: Toluene at 70° C is reacted with concentrated HCl and stoichiometric quantities of paraformaldehyde to obtain chloromethylation of about 98 percent of the toluene in two hours. Concentrated HCl (more than 33 percent) with an excess of CH_2O is circulated and the chloromethyl toluene (57 percent *p*—, 43 percent *o*—) is separated from the aqueous HCl. The HCl is reconcentrated by adding hydrogen chloride recovered by the oxidation and recycled.

Second Stage: The chloromethyl toluene is mixed with 40 percent HNO_3 and heated for one hour to 90° C resulting in a mixture of chlorine free toluic acid and HNO_3. Effluent gases are washed with H_2SO_4, nitrogen oxide going to nitrosesulfuric acid which is recovered as HNO_3 and recycled. HCl goes overhead from the H_2SO_4 washer and is also recycled.

Third Stage: After the second reaction stage the concentration of the HNO_3 is reduced for oxidation under pressure in the third stage. At a pressure of about 20 atms. and 160° C and with the addition of air, the reaction results in nitrogen oxide going to HNO_3 and an effluent of *o*-phthalic acid in solution with HNO_3 and insoluble terephthalic acid. The terephthalic acid is centrifuged and washed with water. This acid is practically free from N, Cl and o-phthalic acid. The o-phthalic acid may be recovered by recrystallization from the mother liquor.

An alternative route may be used which contacts the chloromethyl toluene with 5 percent lime milk at 120-130° C in an iron pressure reactor to convert it to methyl benzyl alcohol. HCl is lost as $CaCl_2$. The saponification product is immediately oxidized under the same conditions as the Third Stage. This alternative route of the Second Stage results in about 20 percent savings in total plant costs since the special equipment for separation of HCl and NO_x are eliminated.

Esterfication: This step can be carried out in a newly developed fluidized bed process. Gaseous methanol, with a suitable catalyst, acts as fluidizing agent and reacting gas. The reaction mixture is separated in a stripping tower giving dimethyl terephthalate.

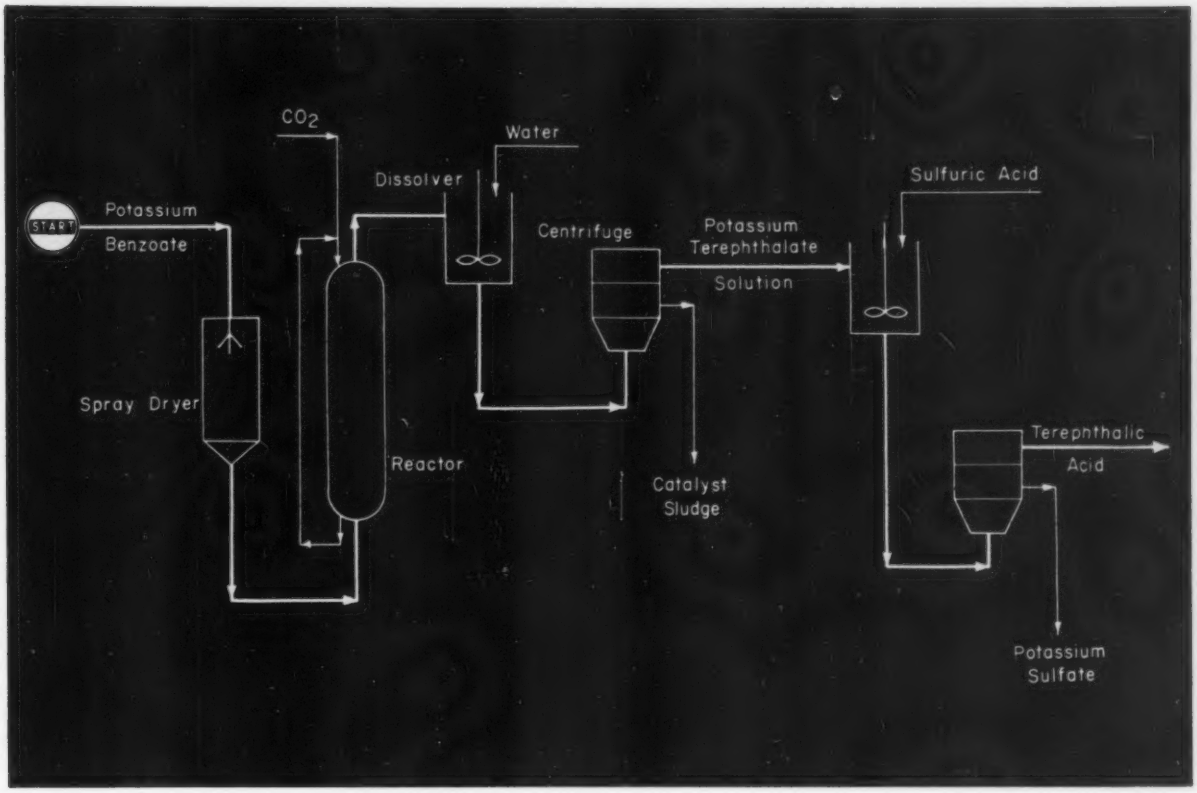
Operating Conditions: As described above.

Pilot Plant: Bergbau-Forschung operates a 200 kg pilot plant for dimethyl terephthalate. Consumption of materials for one ton of dimethyl terephthalate are:

1.0	Ton Toluene	0.5	Ton HCl (loss by saponification)
0.365	Ton Formaldehyde	0.4	Ton $Ca(OH)_2$
0.47	Ton HNO_3	0.375	Ton Methanol

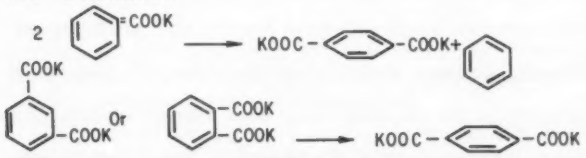
credit can be taken for 0.7 tons of *o*-phthalic acid which is also produced.

References: U.S. Patent 2,966,514, German Patent DAS 1,082,-893; 1,088,474; 1,102,128. Chemical Engineering June 13, 1960, p 71 and July 11, 1960, p 76.



Terephthalic Acid — HENKEL & CIE

Application: Process for making terephthalic acid.
Charge: Benzoic acid, phthalic acid and other benzenecarboxylic acids, as alkali-metal salts, esp. potassium salts.
Product: Terephthalic acid of high purity, especially suitable for making polyester fibers.
Description: The alkali-metal salts of benzenecarboxylic acids are transposed to terephthalates upon heating to temperatures above 350° C as follows.



Dried potassium salts of benzoic acid or of ortho- or iso-phthalic acid are heated in anhydrous form to 400-430° C in the presence of a catalyst under an atmosphere of inert gas (CO_2). The reaction product is dissolved in water, the catalyst filtered off, and the terephthalic acid precipitated from the solution, for example with dilute sulfuric acid.

A number of methods have been developed for recovering the potassium in a form in which it can be re-used directly.

For example, the terephthalic acid can be precipitated from the aqueous potassium terephthalate solution by means of the benzenecarboxylic acids used as starting materials, in which case the precipitation is preferably performed in two steps. In the first step, the less readily soluble monopotassium terephthalate is precipitated. In the second step, it is converted into free terephthalic acid. Alternatively, the monopotassium terephthalate may first be precipitated with carbon dioxide under pressure, and then reacted with the starting carboxylic acid in a second step.

Equipment: The reaction may be carried on as a batch or continuous process, using kiln, vortex-bed, continuous-belt or other similar operation.

Catalyst: The most favorable catalytic activity is provided by cadmium. The most advantageous forms are the benzoate, phthalate, oxide or carbonate. The corresponding zinc compounds have similar but weaker catalytic action. The cadmium is recovered from the filtered residue by roasting and appropriate beneficiation or by dissolving out with HNO_3.

Chemicals Used: If the potassium, catalyst and protective gas are recovered, the process requires no chemicals other than the starting material.

Operating Conditions: The best yields of terephthalic acid are obtained with the potassium salts. Sodium salts give poorer yields. However, an appreciable portion of the potassium may be replaced by sodium without seriously impaired yield.

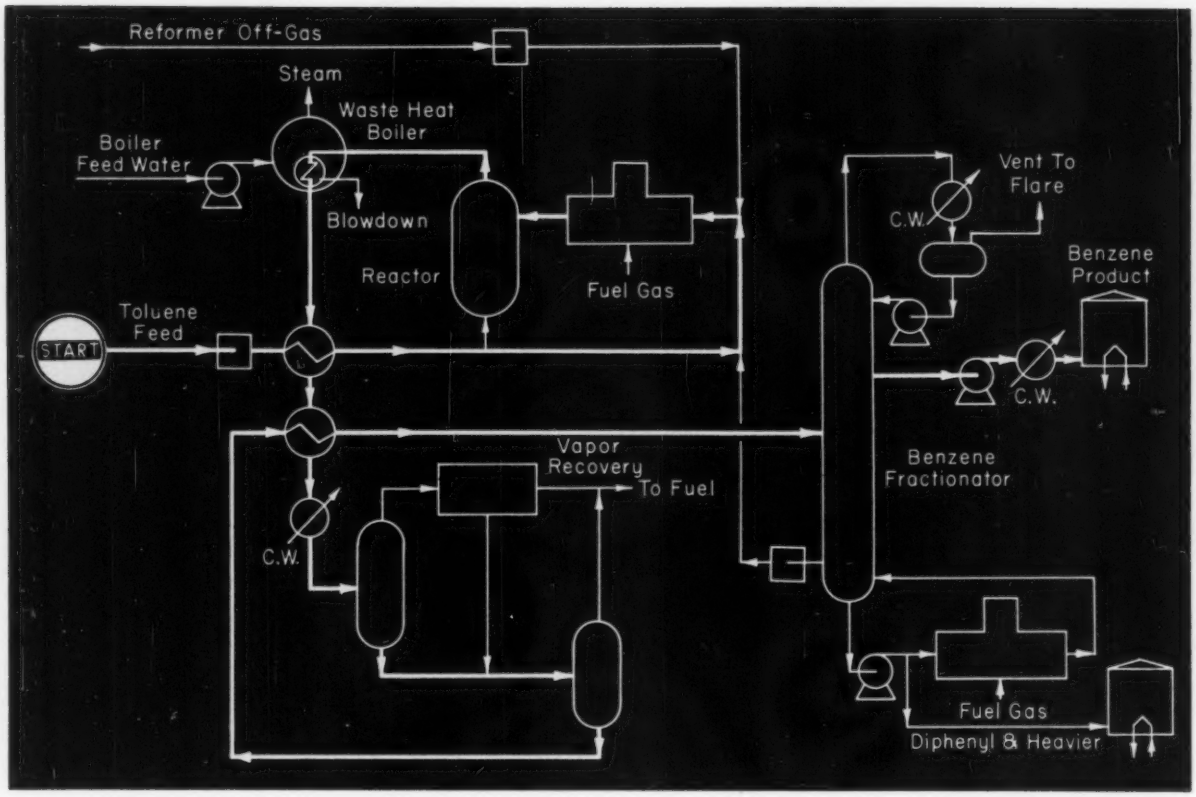
To obtain a high degree of conversion, sufficiently high temperature is essential. Although reaction begins at 350° C, temperatures above 400° C are required for commercial rates, optimum range being 410-430° C. Higher temperatures cause injurious side reactions.

Although good yields are obtainable at atmospheric pressure, the maximum yields are achieved with CO_2 under pressure. With Cadmium catalysts, 3 to 8 atm. is enough for the phthalate transposition; and 10 to 15 atm. for the benzoate reaction. Zinc catalysts require about twice the pressure. Other inert gases, such as nitrogen, give lower yields.

Water and compounds with active hydrogen atoms must be excluded from the reaction. In the preparation of the salts, therefore, care must be taken to see that equivalent quantities of starting materials are put in. Otherwise there will be diminution of yield by decarboxylation. Spray drying is most suitable for dehydrating the salts.

Yields: Under proper conditions, practically quantitative conversion is obtained, with terephthalic acid yields of 95-98 percent. The reaction product is free from ortho- and isophthalic acid. The terephthalic acid produced does not contain aldehydic or other by-products.

Commercial Installations: The process is in production in plants of Kawasaki Kasei Chemicals Ltd., Tokyo (Japan), and Teikoku Rayon Co. Ltd., Tokyo (Japan). A semi-commercial pilot plant is owned by the Badische Anilin- & Soda-Fabrik, Ludwigshafen-am-Rhein (Germany). The engineering know-how of the process is at the disposal of the Lurgi Gesellschaft für Mineralöltechnik m.b.H., Frankfurt-am-Main (Germany).



Thermal Hydrodealkylation (THD)—GULF RESEARCH & DEVELOPMENT COMPANY

Application: A non-catalytic process for thermal hydrodealkylation of toluene and other alkylbenzenes to high purity benzene. The process is also applicable to hydrodealkylation of alkyl naphthalenes to naphthalene or for mixed feed operation for benzene and naphthalene.

Charge Stocks: Benzene—toluene, xylenes, other alkylbenzenes, and/or reformate bottoms, and a hydrogen-containing gas.

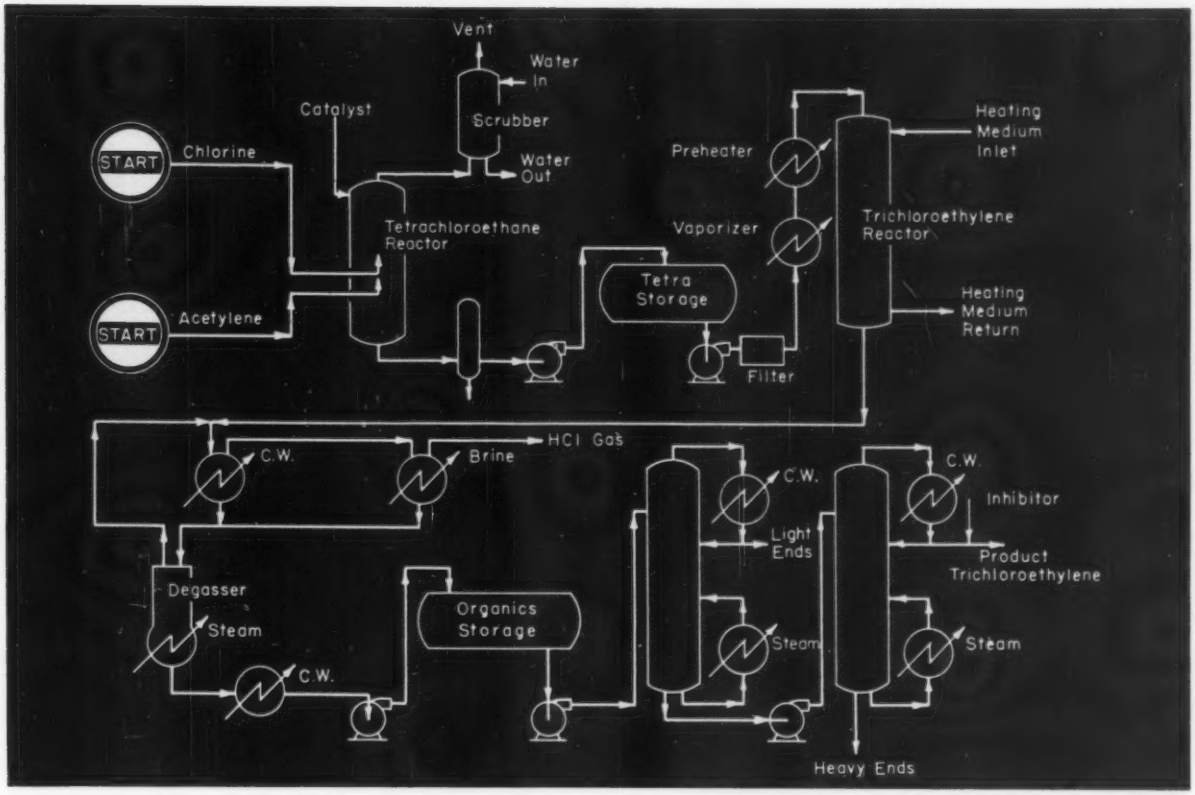
Naphthalene—reformate bottoms, light catalytic gas oils, aromatic extracts, coal tar fractions and a hydrogen-containing gas.

Process Description: Nitration grade toluene from petroleum reformate and a hydrogen-rich gas are heated in a furnace to an elevated temperature and pumped at an elevated pressure into an especially designed reactor. The reactor effluent goes through a waste heat boiler and is then heat exchanged with fresh toluene feed. After heat exchange with fresh feed it is further cooled and the gas is separated as fuel gas. The liquid product is pumped to a fractionating tower where benzene, recycle toluene, and a small amount of heavy product are separated.

Yields: Benzene yields of greater than 95 percent of theoretical are obtained along with a small amount (less than 1 percent) of diphenyl and higher hydrocarbons. For naphthalene production, the yield of naphthalene depends directly upon the concentration of double ring compounds in the charge stock.

Product Quality: The benzene is of very high quality containing less than 1 ppm. of thiophene and is suitable for charging directly to a cyclohexane unit.

Commercial Installations: Three commercial plants are in the design stage.



Trichloroethylene— DETREX CHEMICAL INDUSTRIES, INC.

Application. A process for the manufacture of trichloroethylene.

Charge: Acetylene, 99 percent purity; chlorine, 99 percent purity.

Product: Trichloroethylene, 99+ percent purity.

Description: The process using the above raw materials consists of two main steps (1) the formation of tetrachloroethane (2) the conversion of tetrachloroethane to trichloroethylene by dehydrochlorination.

The tetrachloroethane is produced by feeding controlled amounts of chlorine and acetylene gas into a reactor charged with tetrachloroethane. The desired reaction is:

$$C_2H_2 + 2\ Cl_2 \rightarrow C_2H_2Cl_4$$

Suitable agitation is provided in the reactor to maintain homogeneous conditions and obtain good temperature control. A catalyst such as ferric chloride is usually employed at low concentration. Temperature is held in the range of 70°-85° C for atmospheric pressure operation. Since the reaction is exothermic cooling means must be used to maintain the desired reaction temperature. The process operates continuously with product being withdrawn as formed. Reactor off gases are sent to a scrubber before venting.

Dry tetrachloroethane is pumped from intermediate storage through a filter, vaporizer, preheater, and a catalytic reactor where it is dehydrochlorinated to produce trichloroethylene and HCl as shown by the following equation:

$$C_2H_2Cl_4 \rightarrow C_2HCl_3 + HCl$$

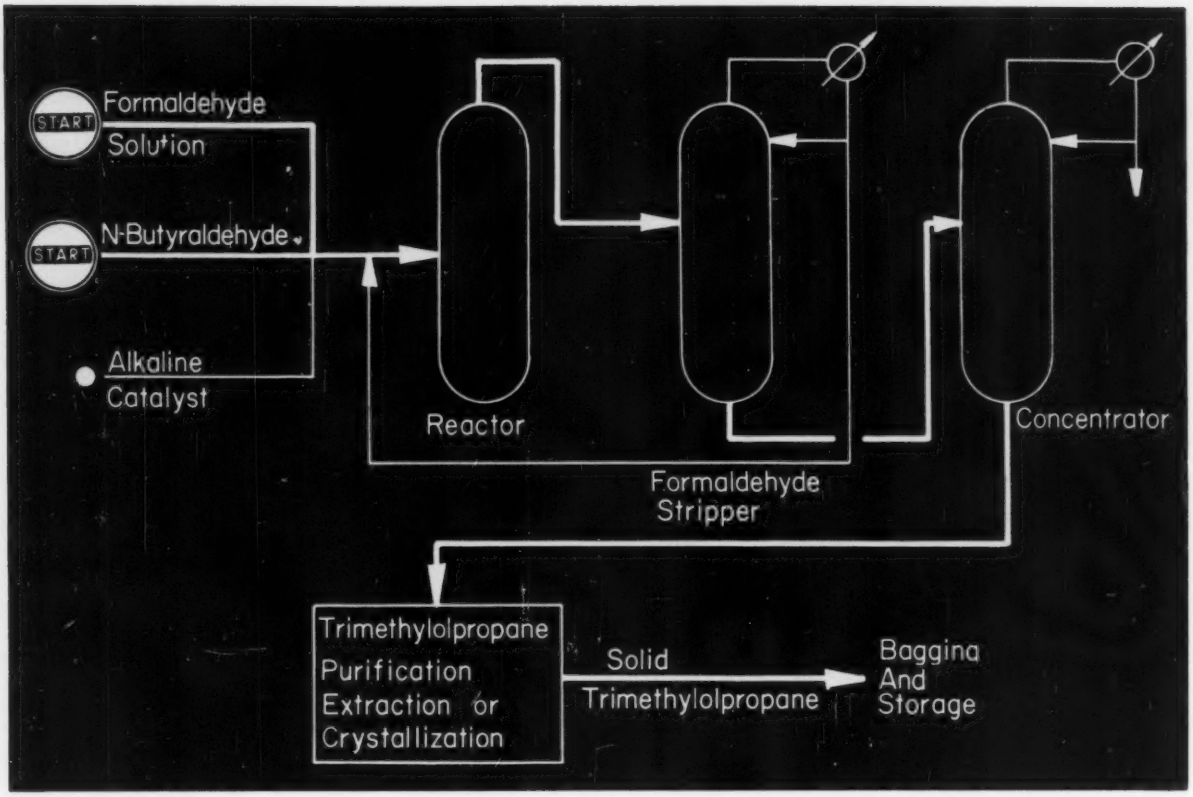
The standard catalyst is barium chloride (30 percent) deposited on carbon. Operating temperature range is 250°-300° C which must be maintaineed by heat input. Conversion is about 90 percent resulting in a product which is then 10 percent tetrachloroethane and 90 percent trichloroethylene. The chlorohydrocarbons are condensed, degassed to remove HCl, and sent to storage. The HCl is scrubbed and cooled to remove organics and is then available for other chemical processes.

The crude trichloroethylene is fractionated to obtain the final pure product which may then be stabilized for specific end uses.

Operating Conditions: Details are given in above text. Additional information can be found in Fiat Final Report No. 843.

Yields: Over-all process yields, acetylene or chlorine to trichloroethylene, are on the order of 90 percent.

Commercial Installations: Trichloroethylene by this or related processes is produced at the following locations: Pittsburgh Plate Glass Co., Barberton, Ohio; Detrex Chemical Industries, Inc., Ashtabula, Ohio; Dow Chemical Company, Freeport, Texas; E. I. DuPont de Nemours and Company, Niagara Falls, N. Y.; Hooker Chemical Corp., Niagara Falls, N. Y. and Tacoma, Wash.



Trimethylolpropane — CELANESE CORPORATION OF AMERICA

Application: A process for the continuous production of trimethylolpropane.

Charge: N-Butyraldehyde, formaldehyde and alkaline catalyst.

Product: Solid trimethylolpropane.

Description: Formaldehyde in excess and normal butyraldehyde are cooled, mixed and fed to the reactor together with the catalyst solution. The two aldehydes undergo an aldol reaction followed by a cross-Canizzaro reaction to form trimethylolpropane. The basic chemical reaction is:

$$\underset{\text{Butyraldehyde}}{CH_3CH_2CH_2CHC} + \underset{\text{Formaldehyde}}{3HCHO} \xrightarrow{M+} \underset{\text{Trimethylolpropane}}{CH_3CH_2C(CH_2OH)_3} + \text{M Formate}$$

Any excess alkali in the reactor effluent is neutralized with acid.

The neutralized reactor stream is preheated and fed to a stripper, where unreacted formaldehyde is recovered. The recovered formaldehyde is recycled to the reactor.

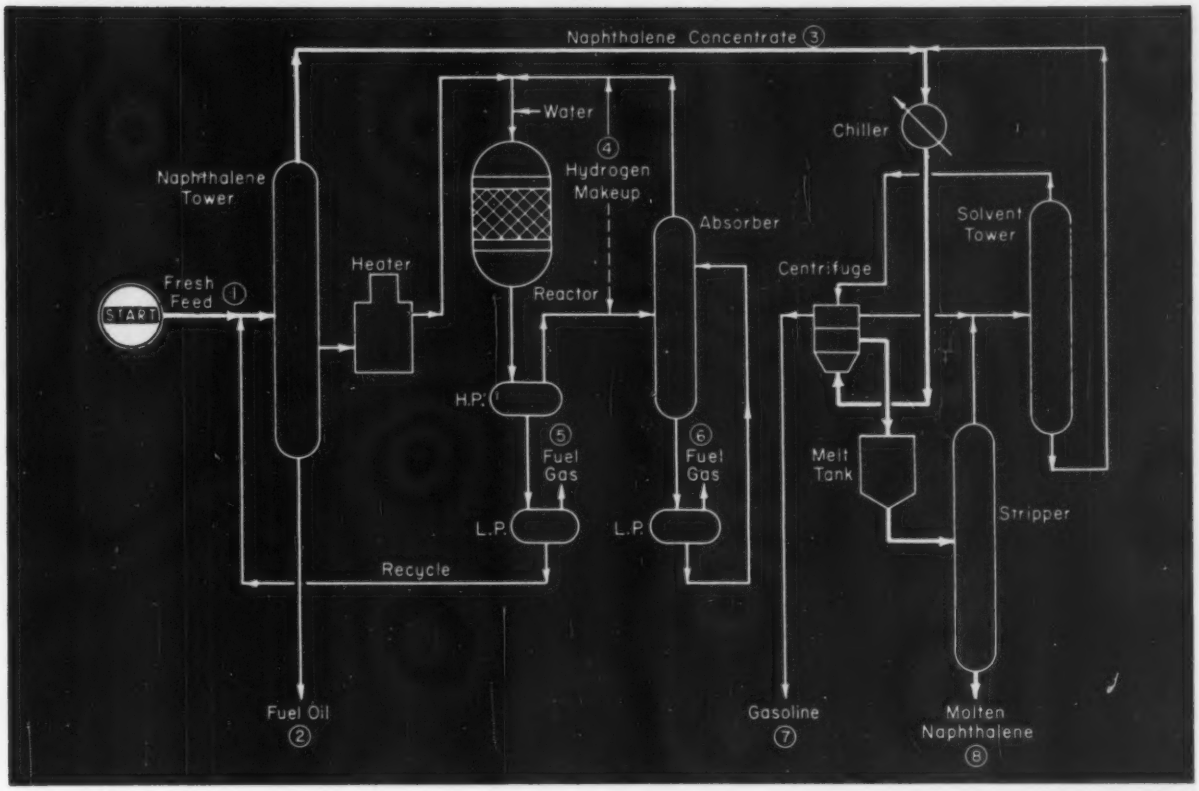
The stripper residue is evaporated at atmospheric pressure to a concentrated water solution. The overhead is discarded.

The residue from the stripper is either crystallized or extracted from the concentrated water solution. The resulting product is dried and bagged for shipment.

Operating Conditions: As noted above.

Commercial Installation: This plant has been in operation since 1956 and is located near Bishop, Texas.

Reference: Anon, "TMP Goes Large Scale," *Chemical and Engineering News,* Vol. 35, No. 52, Dec. 30, 1957, p. 20.



Unidak — UNION OIL COMPANY OF CALIFORNIA

Application: A process for the manufacture of high-quality napthalene.

Charge: Feedstocks may comprise catalytic reformate bottoms, catalytic cycle stocks or the aromatic fraction obtained from steam cracking.

Product: Naphthalene purities up to 80.2° C melting point are obtainable.

Description: The Unidak process uses a highly selective catalyst for the fixed-bed hydrodealkylation of alkylnaphthalenes. This selectivity provides low hydrogen consumption, high liquid yield, and high reaction efficiency. The process is designed for continuous operation with provision for the periodic regeneration of the rugged, thermally stable catalyst.

Fresh feed and recycled reactor product are fed to a fractionator which produces a naphthalene concentrate that is charged to the product separation and purification section, an alkylnaphthalene concentrate that is charged to the reactor, and a small fuel oil cut byproduct.

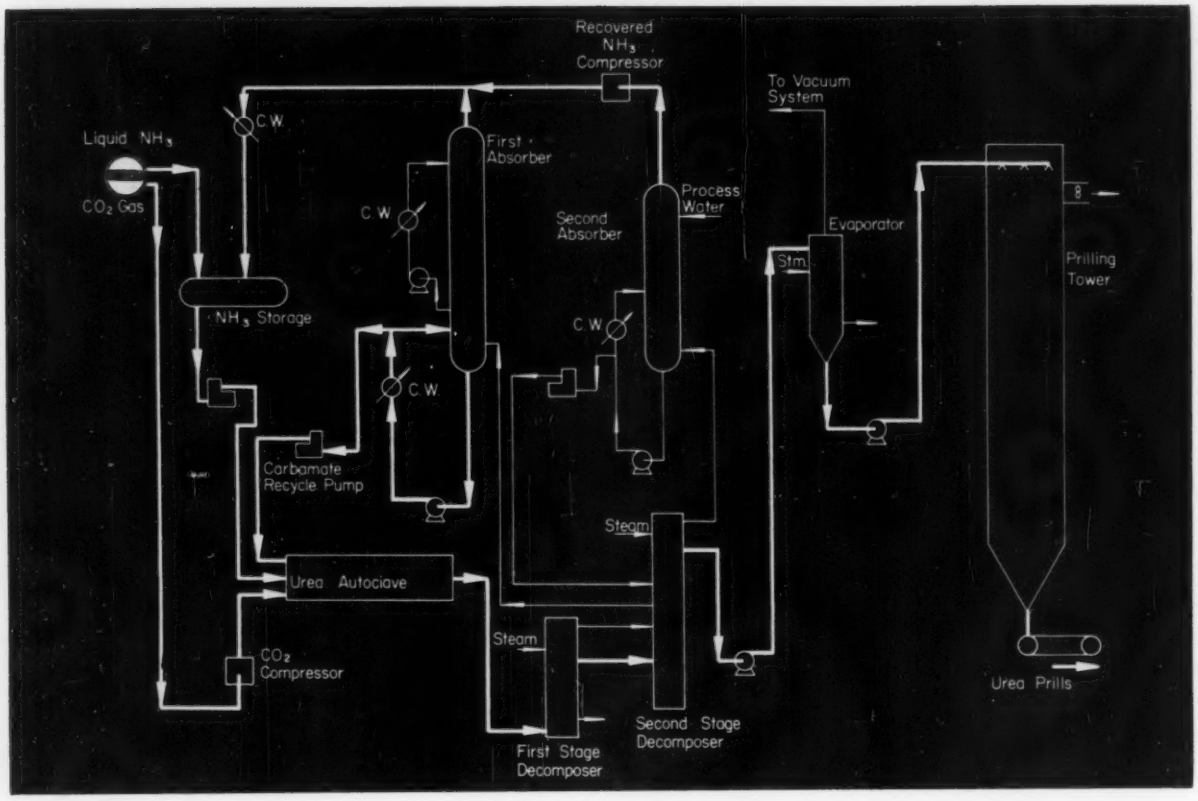
Reactor charge is mixed with hydrogen-rich gas and water and passed through a fixed-bed catalytic reactor. Reactor effluent is heat exchanged with the inlet streams and then sent to a high-pressure gas separator which produces a hydrogen-rich gas stream that is sent to a hydrogen-conservation system consisting essentially of an absorber. Depending on its composition, make-up hydrogen may be processed with the high-pressure separator gas or it may bypass the absorber and be charged directly into the reactor section. Water used to moderate the hydrodealkylation reaction is separated and drawn off. Portions of the water streams may be recycled to the reactor inlet.

Cooling of the naphthalene concentrate from the fractionator produces pure naphthalene crystals. Upon centrifuging of this slurry, mother liquor (heavy gasoline) is retained by the naphthalene cake and is displaced to any degree by washing with a light hydrocarbon solvent, subsequently recovered. A stripper column removes solvent entrained in the naphthalene crystals. Thus all ranges of naphthalene purity may be attained easily by this flexible system.

Yields: Conversion efficiencies of 100% may be expected, based on alkylnaphthalene content of the reactor feed. A typical material balance is shown for the hydrodealkylation of 832 B/CD of catalytic reformate bottoms to produce 50 million pounds per year of high-purity naphthalene. (Stream numbers refer to the flow diagram above.)

Steam No.	1	2	3	4	5	6	7	8
b/cd	832	21	655	....	...	...	380	...
M lbs cd	283	7.7	208	....	...	...	119	137
M scf cd	...	...	...	1070	15.7	910	...	...
% H_2	...	...	...	88	49	40	...	...

Commercial Installations: A 100 million-pound-per-year plant is scheduled for startup late 1961.



Urea — CHEMICAL CONSTRUCTION CORPORATION

Application: A process for the manufacture of urea.

Charge: Ammonia and carbon dioxide.

Description: Urea is produced by reacting ammonia and carbon dioxide at elevated temperatures and pressures to form ammonium carbamate as an intermediate compound. The carbamate is simultaneously dehydrated to produce urea. The reactions are as follows:

$$2\,NH_3 + CO_2 = NH_2COONH_4$$

$$NH_2\,COONH_4 = NH_2\,CONH_2 + H_2O$$

Although the first reaction to carbamate is complete at reaction conditions, the second reaction to form urea is incomplete under all practical conditions. In this process, using a ratio of ammonia to CO_2 of about 3.5:1, a 60 percent conversion of ammonium carbamate to urea is achieved.

CO_2 gas at about 2 psig is compressed to 3200 psi in a 4 stage, water cooled, motor driven, reciprocating type compressor. The CO_2 gas undergoes multistage compression with inter and after stage cooling and separation of water and oil.

The compressed CO_2, liquefied NH_3 from the liquid NH_3 feed pump, and recycled ammonium carbamate solution from the carbamate recycle pump are fed to the urea autoclave where they react to form urea, ammonium carbamate and water.

The autoclave effluent is reduced in pressure to about 300 psig and passed into the tube side of the steam-heated first stage decomposer where unconverted ammonia and CO_2, in the form of ammonium carbamate, are partially decomposed and separated from the urea solution along with most of the excess ammonia. The urea solution, containing dissolved ammonia and CO_2, is reduced to 15 psig and passed through the tubes of the second stage decomposer where most of the residual ammonia and CO_2 are driven off. Gases separated in the first stage decomposer are partially absorbed in dilute ammonium carbamate from the 2nd absorber in the shell of the 2nd stage decomposer providing the heat for decomposition. The urea solution is further degassed by heating with steam.

Ammonium carbamate solution and unabsorbed gas from the shell of the 2nd stage decomposer are passed to the first absorber, operating at a pressure of approximately 250 psig. The gases are partially condensed in the lower packed section by contacting them with a circulating carbamate solution. The heat of reaction is removed in an exchanger by cooling water operating under careful automatic control. The upper packed section operates at a lower temperature in order to condense the residual CO_2 as aqueous carbamate. Heat is removed in an exchanger by cooling water. Pure NH_3 gas leaving the top of the first absorber is condensed and delivered to the NH_3 storage tank.

Gas separated from the urea solution in the second stage decomposer, containing NH_3, CO_2 and water vapor, enters the second absorber. The CO_2 is condensed in the packed section of the tower and the resulting carbamate solution is pumped to the shell of the 2nd stage decomposer. A small amount of process water is added to maintain over-all water balance. Pure NH_3 gas leaving the top of the second absorber is compressed, condensed and returned to the NH_3 storage tank.

Urea solution from the second stage decomposer is pumped to the evaporator where it is concentrated to 99.7 percent under vacuum. The concentrated urea solution is pumped through the spray heads in the prilling tower. The streams formed break up into droplets which congeal to form solid spherical granules.

Process Advantages: (1) Maximum conservation of steam and cooling water through unique method of heat exchange using condensing off gases to decompose carbamate;

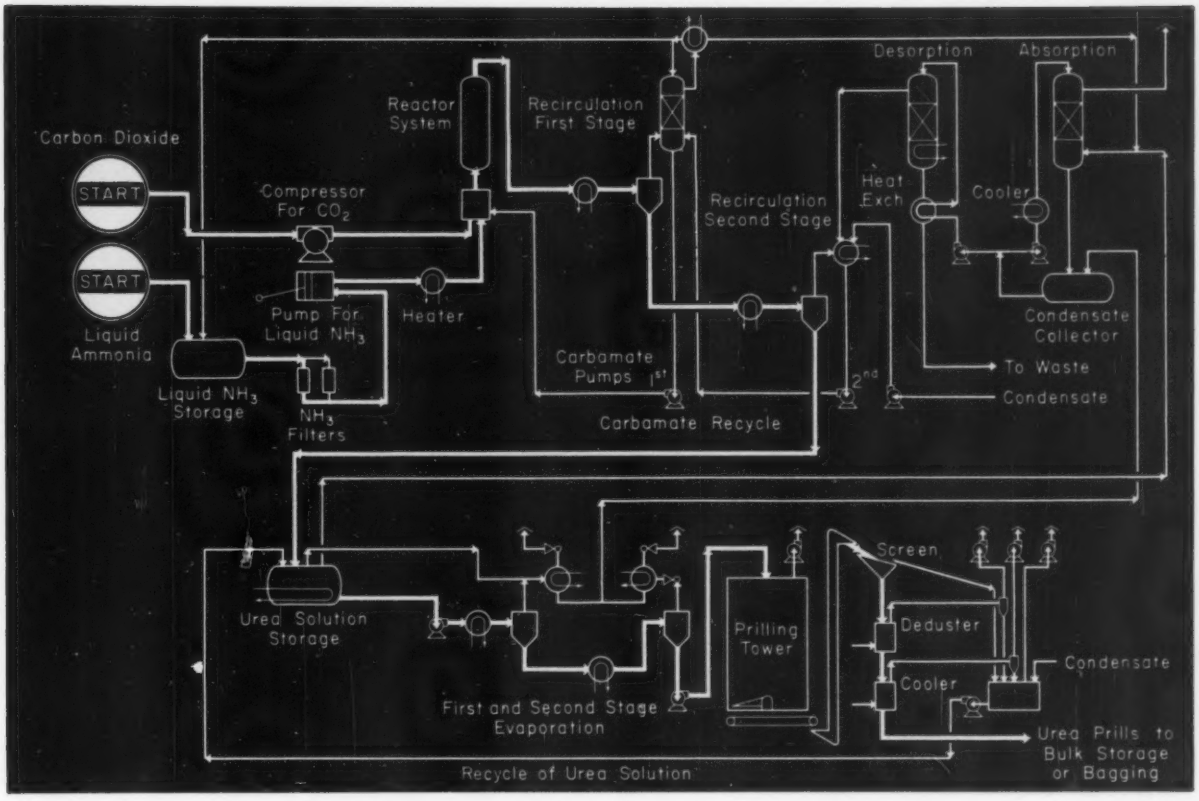
(2) No water from external sources is required for operation of the absorption system. The only water required is a small quantity for maintaining the over-all water balance.

Utilities: The following consumption figures are per short ton of prilled urea in a complete recycle plant.

Electricity	165 KWH
Steam (150 psig saturated)	4,000#
Cooling water (20° F rise)	20,000 gallons

Product: Urea solutions, prills for fertilizer and cattle feed supplement and crystals of high purity for plastics manufacture.

Commercial Installations: Sumitoms Chemical Co., Japan; Nihon Gas Co., Japan; Monsanto Chemical Co., Arkansas; Cyanamid of Canada, Ontario; Co-op. Farm Chem. Association, Kansas; Kobe Steel Co., Pakistan; Fertilizer Corp. of India, Ltd., India.



Urea (DSM)— DUTCH STATE MINES

Application: A process for the manufacture of urea.

Charge: Liquid ammonia and gaseous carbon dioxide.

Products: Urea is produced as aqueous solutions, as prills for fertilizer or cattlefeed-supplement, or as crystals with exceptionally low biuret content for plastics or foliar application.

Description: Three process schemes are available to convert raw materials to products with conversion efficiencies of 45 percent to about 100 percent. Once-through design gives the lower conversions, partial recycle gives intermediate conversions, and total recycle gives the higher conversions. Choice from among these three schemes enables the most economic utilization of ammonia for production of urea or coproduction of urea and ammonium salts such as nitrate or sulfate.

The main difference in three schemes is in the recovery section of the plant. The designs of the reaction section and the finishing section are the same for all schemes. Specifications for raw materials and products are the same for all schemes.

Reactions: Carbon dioxide reacts rapidly and completely with ammonia in the liquid phase to form ammonium carbamate. At reactor operating conditions of about 2,800 psig and 350° F, part of the ammonium carbamate decomposes into urea and water. The extent of decomposition depends mainly upon the amount of ammonia that is present in the mixture. High ammonia concentrations favor decomposition up to about 70 percent. At the stoichiometric ratio of ammonia to carbon dioxide in the reactor mixture, about 45 percent of the carbamate decomposes to urea and water.

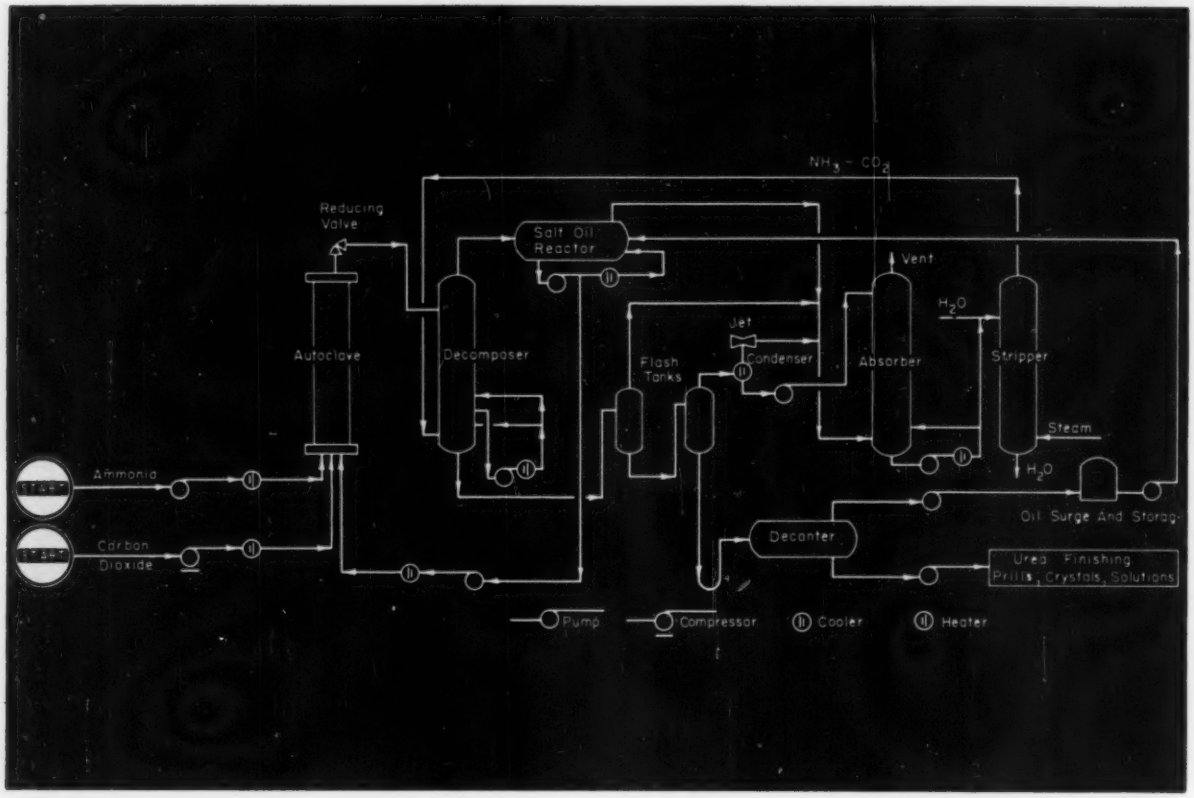
Recovery: In the total recycle process, excess ammonia is flashed from the reactor effluent, condensed and recycled to the reactor. Residual ammonia and carbon dioxide are desorbed from the reactor product and reabsorbed in water in two recirculating stages. At atmospheric pressure, the last traces of ammonia are absorbed in water and concentrated by desorbing under pressure, and then reabsorbing in the second recirculation stage. The carbamate solution is pumped from the second recirculation stage to the first, and finally returned to the reactor. The bottoms product from the ammonia stripper consisting of residual ammonium carbamate, urea, and water, is flashed to near atmospheric pressure in the decomposer to allow further stripping of ammonia and carbon dioxide. The remaining liquid consists of approximately 80 percent urea and 20 percent water.

Finishing: The main separation in the finishing section is between water and urea. Water is evaporated in two stages under progressively higher vacuum. The molten urea product from the second evaporator contains less than 0.3 percent moisture, and the resultant prills contain about 0.6 percent biuret. No further drying of product is necessary. Molten urea is prilled, cooled, and bagged or conveyed to bulk storage. In bulk storage, in a closed shed without air conditioning, the uncoated prilled product does not cake. A modification in the design of the evaporation section gives a prilled product containing less than 0.3 percent biuret.

Yields: For a total recycle process, 100 tons a day of urea computed on 46 percent nitrogen requires about 58 tons of ammonia and 76 tons of carbon dioxide. These quantities allow for nominal losses. For a partial recycle or a once-through plant, the required raw materials are proportional to the conversion efficiency. At 70 percent conversion of ammonia, 100 tons of urea require about 83 tons of makeup ammonia. At 45 percent conversion, makeup ammonia is about 129 tons. For a 100-ton urea plant, offgas ammonia to ammonium salt production is 0 for total recycle, 25 tons for 70 percent conversion, and 71 tons for 45-percent conversion.

Materials: Materials for the reactors, decomposer, evaporators, and other equipment in high temperature service are stainless steels of the 300 Series. Linings of lead, silver, or other precious metals are not used. The use of oxygen under U.S. Patent 2,727,069 controls corrosion at a negligible rate.

Commercial Installations: Seventeen plants are presently in operation or under construction in eleven different countries. Total Capacity is about 5,000 tons per day, or equivalent to 1.7 million tons a year. Plant sizes range from 70 tons a day to about 500 tons a day. The bulk of the production is by the total recycle design. Arthure G. McKee & Co. has designed and is constructing a plant for Solar Nitrogen Chemicals Inc. The first commercial plant producing prills with less than 0.3 percent biuret, is being engineered and designed by C F Braun & Company, and will start production in 1962.



Urea— FOSTER WHEELER CORPORATION

Application: A process for the manufacture of urea.

Charge: Ammonia and carbon dioxide.

Products: Prilled solid urea, technical grade crystals, solutions.

Description: Urea synthesis, in the Pechiney-Grace process, essentially is achieved by the non-catalytic reaction of ammonia and carbon dioxide at a pressure of 3000 psig. The outstanding feature of the process is the use of a neutral oil in which unconverted feed gases in the form of an ammonium carbamate slurry is recycled to the reactor. The products of the reaction are highly corrosive and the neutral oil circulating medium minimizes attack of metal parts and also moderates temperature variations in the reactor.

Carbon dioxide compressed to reaction pressure, treated to remove any residual sulfur and oxygen, is preheated and charged to the reactor. Liquid anhydrous ammonia is preheated and also enters the reactor. The recycle stream containing 35-40 percent ammonium carbamate solid in a highly dispersed slurry-in-oil also enters the reactor. The primary reaction is to form ammonium carbamate from ammonia and carbon dioxide.

This is a highly exothermic reaction and supplies the heat for the secondary reaction, the dehydration of carbamate to urea and water, which is endothermic. The oil carrier thus serves as a thermal fly wheel storing the heat liberated by the first reaction and releasing it for the second reaction.

The effluent from the reactor, viz., urea, unreacted carbamate, water and carrier oil flows through a pressure reducing valve from the 3000 psig reactor pressure to approximately 60 psig and into the decomposer where heat is applied to decompose carbamate into ammonia and carbon dioxide.

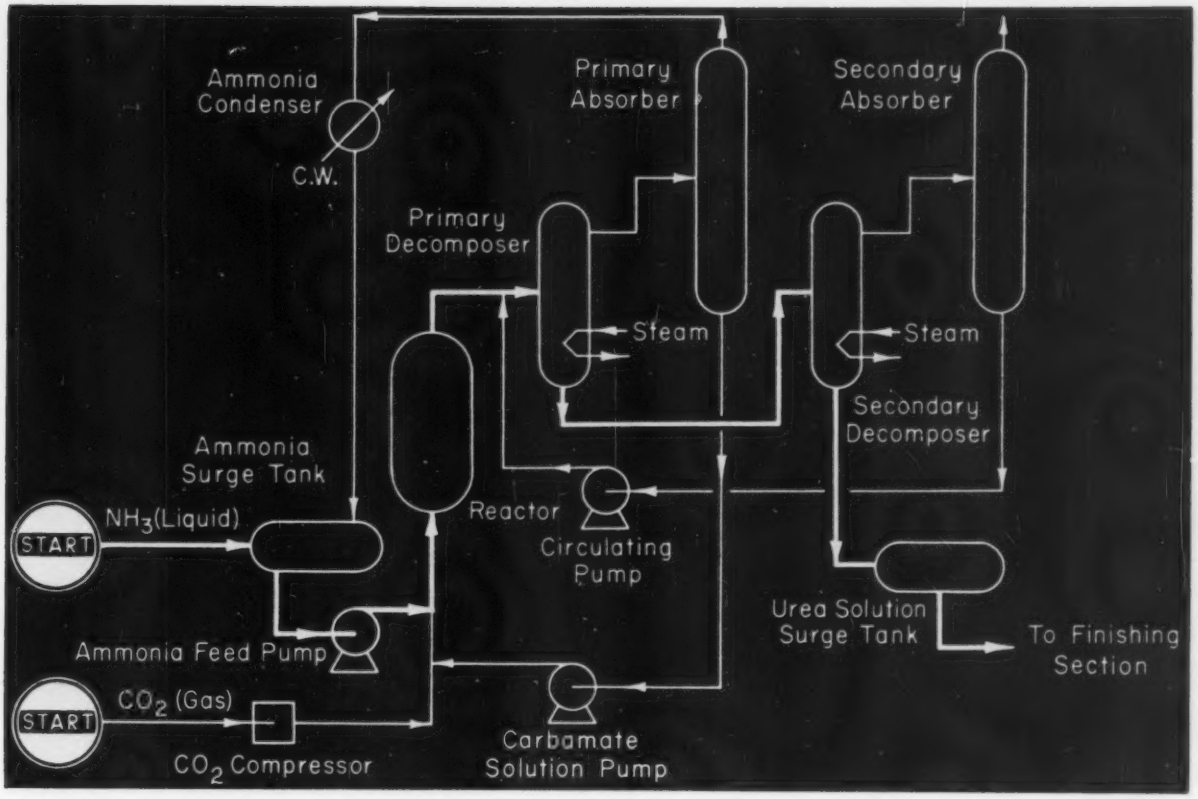
The aqueous urea solution and oil flows through atmospheric and sub-atmospheric flash systems to the decanter where the carrier oil settles as a top layer and is pumped to the oil surge and storage tank. The aqueous urea solution withdrawn from the bottom of the decanter is pumped to the urea finishing sections.

Uncoverted ammonia and carbon dioxide gases, from the decomposer, flow to the salt oil reactor where they combine to form solid ammonium carbamate finely dispersed in the circulating oil. This recycle stream of ammonium carbamate and oil is pumped back to the synthesis autoclave.

Ammonia and carbon dioxide gases released in various parts of the unit flow to an absorption-recovery section and are recycled to the decomposer.

Operating Conditions: Essential operating conditions are given in the above description.

Commercial Installations: Grand River Chemical Division of Deere and Company, Pyor, Okla., Grace Chemical Co., Division of W. R. Grace & Co., Memphis, Tenn. and 330 Ton/day installation by Government of Indonesia.



Urea (Lummus-Lonza)— THE LUMMUS COMPANY

Application: A process for the production of urea.

Charge: Gaseous carbon dioxide and liquid ammonia.

Production: The production of urea in various forms such as prills, crystals, molten mass and solutions of varying concentrations.

Description: The flow diagram illustrates the Lummus-Lonza Urea Process for the production of urea based on the total recycle of unconverted ammonia and carbon dioxide. The process may also be utilized for once-through and partial recycle operation.

Liquid ammonia and gaseous carbon dioxide in a selected ratio together with recycled carbamate are introduced into the reactor. The proper selection of feed ratios and reactor temperatures and pressures permit the synthesis reaction to occur at optimum conditions of conversion. Under these selective conditions approximately 70 percent of the carbon dioxide is reacted and therefore a minimum amount of carbamate need be recycled. The reaction between ammonia and carbon dioxide takes place between 160 to 220° C and 200 to 350 atmosphere. The reaction is exothermal and shown by the following equations:

$$2\,NH_3 + CO_2 \quad NH_4\,CO_2\,NH_2$$

$$NH_4\,CO_2\,NH_2 \quad (NH_2)2\,CO + H_2O$$

The urea synthesis operation is carried out in a minimum sized high pressure vessel. Construction of the reactor is with a commercially available alloy liner.

The effluent from the reactor containing urea, ammonium carbamate and water is reduced to an intermediate pressure in the primary decomposer. Ammonia and carbon dioxide are flashed, separated from the residual liquid and flows to the primary absorber. The liquid flows to a secondary decomposer operating near atmospheric pressure where it is heated to complete the decomposition of carbamate. Ammonia and carbon dioxide from this decomposition step are absorbed in the secondary absorber.

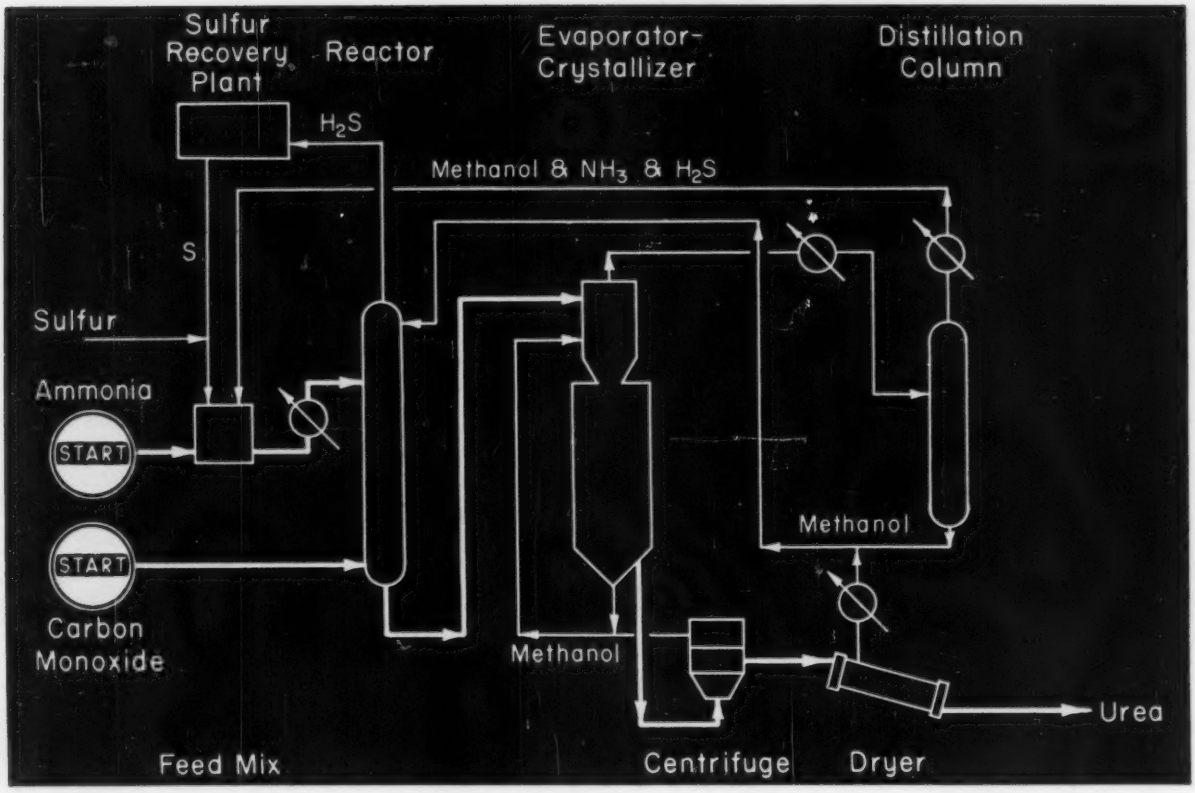
The urea solution from the secondary decomposer flows to a surge tank to be pumped to the finishing section for evaporation and solidification into desirable product form.

The gases from the first decomposer are recovered in the primary absorber in an aqueous solution. The tower is designed to concentrate most of the ammonia which leaves overhead and after condensation is combined with fresh ammonia feed. The separation takes place at a pressure which permits the use of cooling water for the condensation of ammonia and eliminates the need for refrigeration. The carbamate solution leaves the bottom of the tower and is recycled back to the reactor.

The gases from the secondary decomposer are recovered in the secondary absorber as an aqueous solution. This solution is returned to the primary decomposer.

The use of a water solution in the recovery of ammonia and carbon dioxide provides a recycle stream free of any contaminating material not previously fed to the system. Carbon dioxide pressure costs are reduced as the carbon dioxide is recycled as a liquid instead of as a gas. The recovery and recycle system described here permits 99 percent conversion of both the ammonia and carbon dioxide fed.

Commercial Installations: Fertilizentes del Bajio, Selemenca, Mexico (under construction).



Urea — MONSANTO CHEMICAL COMPANY

Application: A new synthesis of urea under mild conditions of pressure and temperature.

Charge: Gaseous ammonia, sulfur, carbon monoxide, solvent methanol and hydrogen sulfide.

Products: Crystalline urea of 99.6 percent purity and gaseous hydrogen sulfide.

Description: The Lion Oil Company, a division of Monsanto Chemical Company has developed a pilot plant process for the production of urea from ammonia, sulfur and carbon monoxide. In contrast to the conventional urea processes, the pressures are low, ranging from 200-300 psig, while the temperature is usually held at 212° F. The stoichiometric equation is

$$CO + 2\,NH_3 + S \rightarrow NH_2CONH_2 + H_2S$$

The sulfur is recovered from the hydrogen sulfide by one of the conventional processes and recycled.

The reaction is carried out in the presence of a solvent such as methanol. It has been found convenient to make up a feed solution by dissolving the sulfur in ammoniacal methanol and adding some hydrogen sulfide so as to get a more concentrated sulfur solution. The hydrogen sulfide does not take part in the reaction. The sulfur may be best handled in the melted state.

The reaction is conducted in a specially designed sieve-plate reactor made of stainless steel. It is operated in a counter-current manner.

Feed: Carbon Monoxide: Although a feed gas containing lower concentrations of carbon monoxide may be used, gases having 85 to 95 percent are preferred. Small amounts of inerts such as nitrogen do not interfere. Iron carbonyl and carbon dioxide are undesirable.

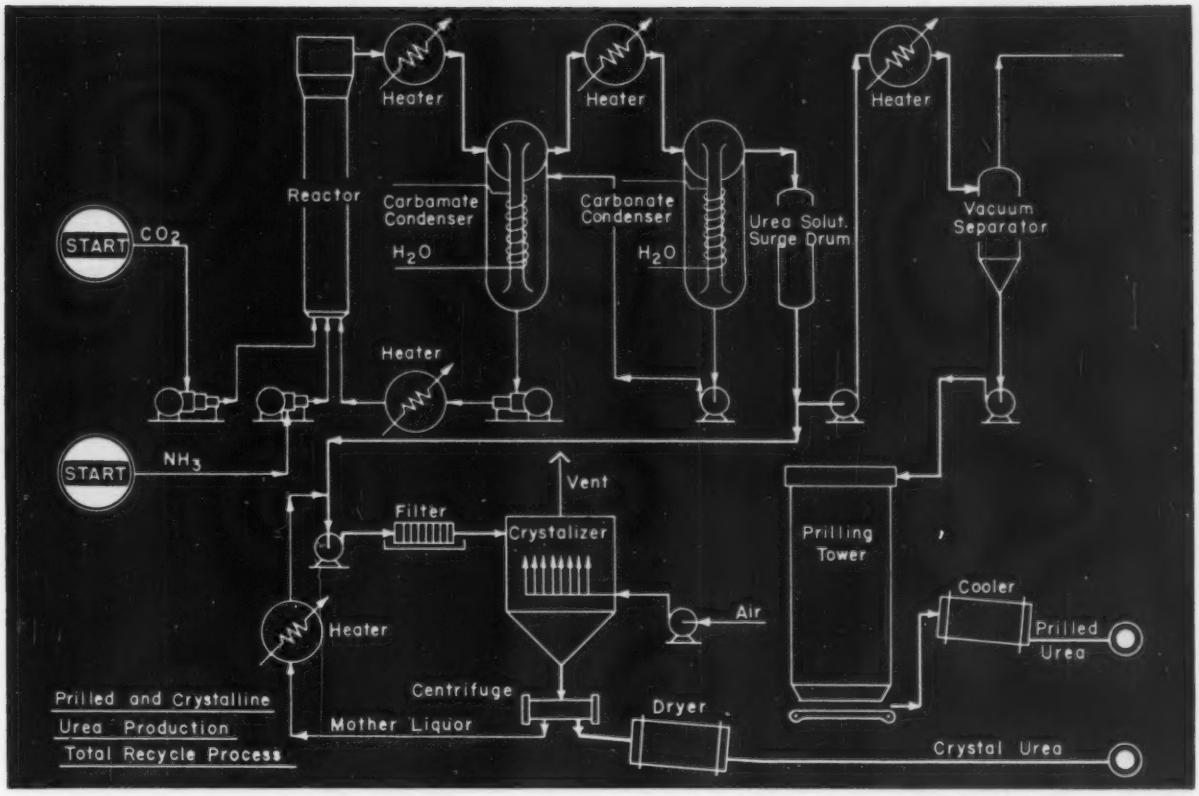
Sulfur and Ammonia: A feed solution having the following composition gives satisfactory results:

NH_3 25 percent, H_2S 4 percent, S 20 percent, and methanol 51 percent.

This is fed at a temperature of 136° F to the reactor by a pump made of nickel-molybdenum alloy, while the carbon monoxide is injected near the bottom at a pressure of 250 psig. The temperature is held at 212° F in the reaction section. The urea product containing excess ammonia and some hydrogen sulfide passes to the evaporator-crystallizer where the methanol, ammonia and hydrogen sulfide are removed overhead. The distillation column separates pure methanol which recirculates to a recovery section in the reactor preventing losses of ammonia from the reactor. The urea crystals from the crystallizer are centrifuged and dried to recover methanol. The product contains more than 99 percent urea.

Yields: Conversions per pass of sulfur to urea approach 100 percent, for ammonia usually 85-95 percent and for carbon monoxide 60-75 percent. Ultimate yields based on ammonia and sulfur are better than 99 percent under good operating conditions. The carbon monoxide is usually not recycled due to the presence of other impurities.

References: U.S. Patents 2,857,431; 2,857,430; British Patent 818,864.



Urea— MONTECATINI

Application: A process for the manufacture of synthetic urea.

Charge: Liquid ammonia and gaseous carbon dioxide free from sulfur compounds and having, at least, a 97 percent purity.

Product: Fertilizer grade urea in spherical granules or technical grade urea in crystals.

Description: Ammonia and carbon dioxide are pressurized into the reactor where, at a pressure of 2700 psig and at a temperature of 360° F. they react forming ammonium carbamate, which in turn is converted into urea plus water.

It is necessary to maintain in the reactor, because of its favorable influence upon the conversion of carbamate into urea, an excess of ammonia in respect of the stoichiometric value. In fact, the extent of urea formation is limited by equilibrium considerations so that in the reactor effluent there are, in addition to urea and water, some carbamate and free ammonia. The last two components must be separated from the urea solution.

The reactor effluent is first expanded to 300 psig. During this operation a gaseous mixture of NH_3 and CO_2 is freed and after condensation is recycled to the reactor. By means of this liquid recycle it is possible to return to the reactor a large portion of unreacted ammonia and carbon dioxide as an aqueous solution. The remaining NH_3 and CO_2 are vaporized from the urea solution by means of a second expansion step to about atmospheric pressure.

The gaseous mixture which is thus made available is condensed and sent back to the cycle by introducing it into the carbamate condenser.

This method of recycling NH_3 and CO_2 as an aqueous solution represents a substantial improvement over other methods which recover the same components in the gaseous state and recycle them to the reactor after compression. In this way, remarkable savings can be achieved in electric power consumption and greater simplicity in the construction design of the plant.

The urea solution, free from NH_3 and CO_2 is further concentrated in a vacuum concentrator and is then pumped to sprayers in a prilling tower. Here the solution is subdivided in the form of small droplets which, falling vertically in an air stream flowing upwards, are solidified, forming prills.

Prilled urea is particularly suitable for agricultural uses. The crystalline product having a higher purity is preferred for technical uses and is obtained from the concentrated urea solution by means of crystallization and centrifugation.

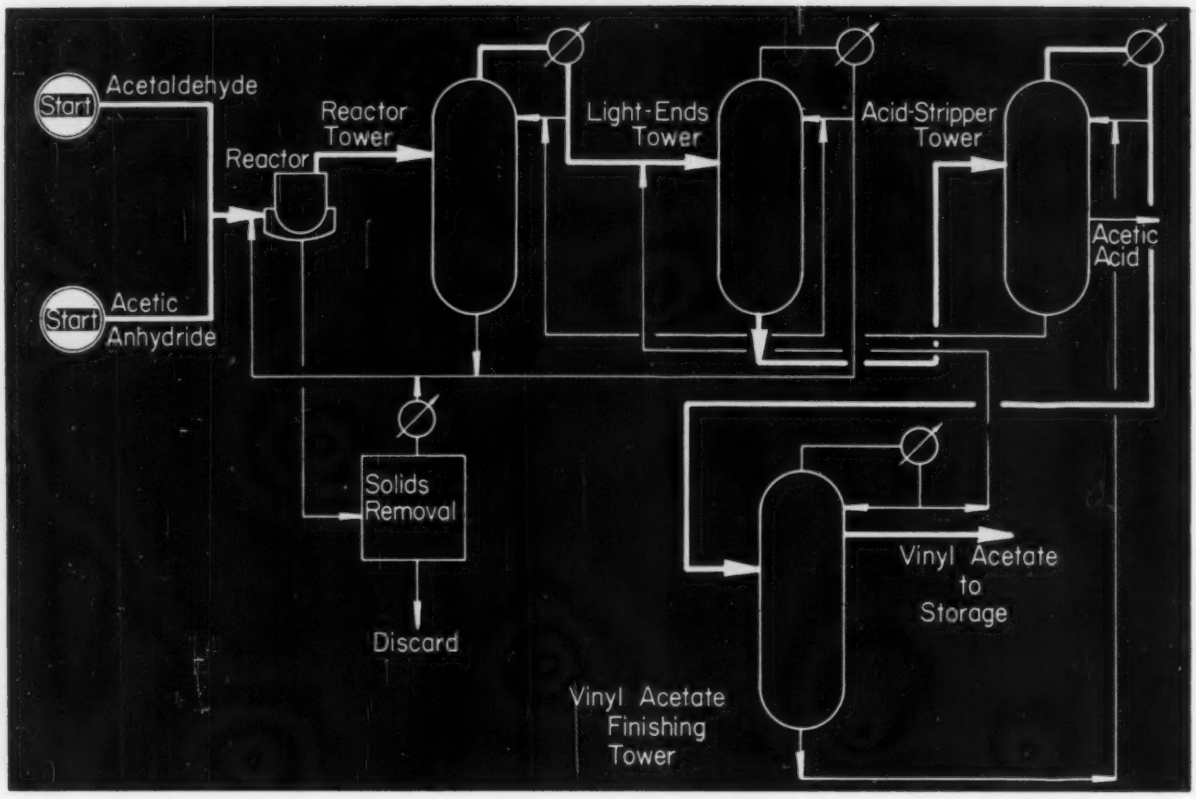
Operating Conditions: As already mentioned, the reactor pressure is from 2500 to 2800 psig and a temperature of 350° to 360° F. is maintained.

Yields: Conversion of ammonia and carbon dioxide into urea is total. Raw material requirements per ton of urea (46 percent N_2) are 0.600 ton of NH_3 and 0.770 ton of CO_2.

Corrosion Problems: Mild and carefully controlled reaction conditions are used in this new process to eliminate corrosion, a major problem in urea plants. By careful selection of composition and temperature in the reactor, it is possible to use with excellent results, commercially available stainless steel for reactor lining and for other surfaces exposed to corrosion.

Commercial Installations: 35 commercial plants are presently in operation or under construction all over the world, with a total annual capacity of 1 million metric tons of urea.

U.S. Plants in Operation: Shell Chemical Corp., Ventura, Calif.; Spencer Chemical Co., Vicksburg, Miss.; Spencer Chem. Co., Henderson, Ky.; SunOlin Chem. Corp., North Claymont, Del. Under construction: Armour & Co., Cherokee, Ala.



Vinyl Acetate— CELANESE CORPORATION OF AMERICA

Application: A process for the continuous manufacture of monomeric vinyl acetate.

Charge: Acetic anhydride and acetaldehyde.

Product: Vinyl acetate monomer, 99.9 percent purity.

Description: Acetaldehyde and acetic anhydride are reacted in the liquid phase at an elevated temperature in the presence of a catalyst. The basic chemical reactions are:

$$CH_3CHO + (CH_3CO)_2O \longrightarrow CH_3CH(OOCCH_3)_2$$

Acetaldehyde Acetic Anhydride Ethylidene Diacetate

$$CH_3CH(OOCCH_3)_2 \rightarrow CH_3COOH + CH_2=CHOOCCH_3$$

Ethylidene Diacetate Acetic Acid Vinyl Acetate

The reaction products are removed rapidly from the reactor as overhead. A liquid stream is continuously withdrawn from the base of the reactor.

The reactor overhead is fed to the vinyl acetate reactor tower where vinyl acetate and acetic acid are removed as overhead. The reactor-tower residue is returned to the vinyl acetate reactor.

The reactor-tower overhead is transferred to a light-ends tower where acetaldehyde and other low boiling materials are removed overhead for recycle to the vinyl acetate reactor. The light-ends tower residue is fed to the acid-stripper tower.

The liquid stream from the bottom of the reactor is transferred to a solids-removal flasher, operating under reduced pressure, where acetaldehyde and acetic acid are recovered overhead and returned to the vinyl acetate reactor.

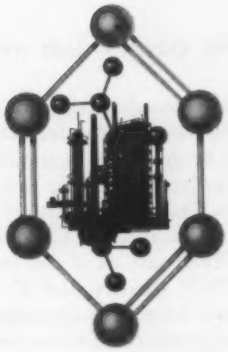
The light-ends tower residue is transferred to an acid-stripper tower where vinyl acetate and light-ends are removed as overhead. This overhead is transferred to the vinyl acetate finishing tower. In this acid-stripper tower acetic acid is removed as a side stream. The residue stream is recycled to the vinyl acetate reactor tower and the light-ends tower.

In the vinyl acetate tower the finished vinyl acetate is removed as a side stream. The overhead contains vinyl acetate along with some light-ends and this stream is returned to the light-ends tower. The residue from this tower is recycled to the acid-stripper tower.

Inhibitor is added to the finished vinyl acetate and the inhibited product is pumped to storage.

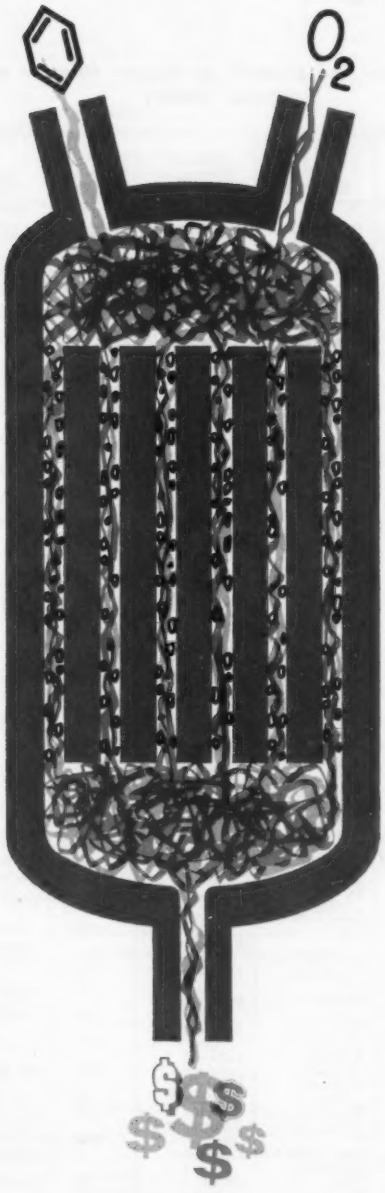
Operating Conditions: As noted above.

Commercial Installation: This plant has been in operation at a location about 6 miles from Pampa, Texas, since 1953.



PART 1: INTRODUCTION

Combine Oxygen and Hydrocarbons for Profit



Starting with background material, this part introduces chemical fundamentals, thermodynamics, stoichiometry, kinetics, and catalysts for oxidation of hydrocarbons

Marshall Sittig
Princeton, N. J.

Oxidation is perhaps the most important single process for converting hydrocarbon raw materials to profitable products. In 1954, the statement was made that "Oxidation continues to be the most promising of the major process reactions used industrially for the conversion of hydrocarbons to useful organic products."[229A] Then, in 1958, Toland[359A] pointed out that "The period since 1955 has seen a new wave of interest and expansion in the controlled oxidation of organic compounds."

By far the most important tool in effecting oxidation reactions is oxygen itself. For many years, it was used in the form of air. Now that air separation plants are dotting the landscape, high purity elemental oxygen is available in large volumes at decreased cost. These two oxidents—oxygen and air—are then in competition for the major market involved in hydrocarbon oxidation processes. While such competition has been noted previously in the literature, the economic and operating pros and cons have not been delineated. This article will attempt to discuss, where possible, the relative advantages and disadvantages of air and oxygen in specific process applications so that some degree of economic sophistication may be imparted to the chemist or engineer contemplating a new oxidation process or the revision of an old one. This will be presented against an up-to-date review background covering all hydrocarbon oxidation processes.

There have been other reviews of oxidation processes but many of them devoted solely either to vapor-phase or liquid-phase oxidations. Further, the practical and economic flavor has been absent from most of these reviews in any case. Perhaps the closest prior approach to the general coverage of the present work was afforded

by the Proceedings of the Conference on Oxidation Processes held in Amsterdam, May 6-8, 1954.[112] Other general coverage has been given by Marek. [230] Also, joint symposia have been held in London in 1948 and 1958 by the Low Temperature Group of the Physical Society and by the Institution of Chemical Engineers and reported in the Transactions of the Institution of Chemical Engineers.[186, 187] Medley and Cooley of Celanese Chemical Company have recently reviewed hydrocarbon oxidation with emphasis on reaction mechanisms.[242]

Most recently, the London Section of the Society of Chemical Industry sponsored a symposium on "Oxidation Processes in Chemical Manufacture" on September 28-29, 1961.

One interesting specialized review is that by Margolis on the catalytic oxidation of hydrocarbons as a means for the synthesis of monomers.[232] This review covered ethylene oxide, acrolein, HCN, etc.

In this review, the term "hydrocarbons" has been "stretched" to include some oxygen compounds and a few sulfur compounds. The oxygen compounds (methanol, isopropanol, etc.) have been included because they fit within a petrochemical framework and because the process (as in the case of liquid phase oxidation of acetaldehyde to acetic acid) furnish illustrative examples of the economics of oxygen application which can be applied to pure hydrocarbon reactions. The few examples of sulfur compound oxidation have been cited because of the occurrence of sulfur compounds in petroleum and the close kinship of desulfurization reactions to hydrocarbon chemistry.

Background and growth of the field

From the standpoint of oxygen consumption, oxygen uses in the chemical industry now account for approximately 40 percent of United States oxygen capacity or about 8,980 tons per day of oxygen. Table 1 gives a breakdown of this consumption figure by process and shows its relation to other oxygen-consuming industries. Table 2 shows a similar breakdown for world industry.

Oxygen plant requirements for chemical processing differ from requirements for oxygen plants in the steel

TABLE 1—An Analysis of Oxygen Uses in U.S. Industry in 1961

	Tons/Day
Chemical Industry	
For synthesis gas	
For ammonia	2,700
For methanol	360
Acetylene	4,180
Ethylene oxide	1,070
LPG oxidation	380
Acrolein and hydrogen peroxide	200
Chlorine	30
Phthalic anhydride	0
Urethanes, ozone, etc.	60
	8,980
Steel Industry	10,000
Missiles	2,000
Miscellaneous (Medical, glass, cutting, etc.)	1,800
Total	22,780

TABLE 2—Breakdown of World Oxygen Capacity and Uses

Country	For Chemicals	For Steel & Misc.	Total
United States	8,980	13,800	22,780
West Germany	4,220	4,045	8,265
Italy	4,115	305	4,420
United Kingdom	1,200	1,900	3,100
France	1,040	1,460	2,500
Spain	1,185	160	1,345
Holland	1,050	380	1,430
Belgium	660	1,470	2,130
Canada	495	805	1,300
South America	180	265	445
Miscellaneous (excluding USSR)	4,355	3,510	7,865
	27,480	28,100	55,580
USSR (estimate)	.....	.....	17,000
World Total			72,580 Tons/day

TABLE 3—Types and Locations of Oxygen Plants in the U.S. Chemical Industry

Company	Location	Primary Chemical Produced	Tons O_2 Per Day	Oxygen Process
Columbia River Chemical	Pasco, Wash.	Ammonia	125	L'Air Liquide
Coop Farms Chemical Association	Lawrence, Kan.	Ammonia	150	Messer
Deere Company	Pryor, Okla.	Ammonia	150	Messer
Dow Chemical	Midland, Mich.	Ammonia	30	Air Products
Gonzalez Chemical Industry	Puerto Rico	Ammonia	110	Air Products
Grace Chemical	Memphis, Tenn.	Ammonia	225	Air Products
Hercules Powder, Mississippi River Fuel	Pinole, Calif.	Ammonia	115	L'Air Liquide
Northern Chemical Industry	Selma, Mo.	Ammonia	170	L'Air Liquide
St. Paul Ammonia	Searsport, Maine	Ammonia	110	Air Products
Smith Douglas Chemical	Pine Bend, Minn.	Ammonia	180	L'Air Liquide
Spencer Chemical	Houston, Texas	Ammonia	105	L'Air Liquide
National Distillers	Vicksburg, Miss.	Ammonia	200	Air Products
Calumet Nitrogen Products	Tuscola, Illinois	Ammonia	70	L'Air Liquide
Petroleum Chemicals, Inc.	.....	NH_3	90	L'Air Liquide
Dow	Lake Charles, La.	NH_3	90	L'Air Liquide
Du Pont	Plaquemine, La.	NH_3	150	L'Air Liquide
American Cyanamid	Belle, W. Va.	Ammonia and methanol	840	Linde Co.
Dow Chemical	Avondale, La.	Acetylene and ammonia	900	German Linde
Monsanto Chemical	Velasco, Texas	Acetylene	400	Air Products
Rohm & Haas	Texas City, Texas	Acetylene	600	Hydrocarbon Research
Union Carbide Chemical	Houston, Texas	Acetylene	300	L'Air Liquide
Diamond Alkali	Texas City, Texas	Acetylene	480	Linde Co.
Monochem	Deer Park, Texas	C_2H_2	320	Linde Co.
Tennessee Gas	Geismar, La.	C_2H_2	550	L'Air Liquide
Dow Badische	Houston, Texas	C_2H_2	730	Hydrocarbon Research
Calcasieu Chemical	Freeport, Texas	C_2H_2	50	L'Air Liquide
Wyandotte Chemical	Lake Charles, La.	Ethylene oxide	160	L'Air Liquide
Sun Olin	Geismar, La.	Ethylene oxide	180	German Linde
Olin Mathieson	Claymont, Del.	Ethylene oxide	90	L'Air Liquide
Union Carbide Chemical	Brandenburg, Ky.	Ethylene oxide	140	Linde Co.
Celanese Chemical	Institute, W. Va.	Ethylene oxide	500	Linde Co.
Warren Petroleum	Bishop, Texas	LPG oxidation	350	Air Products
Allied Chemical	Conroe, Texas	LPG oxidation	30	Air Products
Shell Chemical	Hopewell, Va.	Chlorine	30	Stacy-Dresser
Mobay	Norco, La.	Acrolein and H_2O_2	200	German Linde
Emery Industries	Natrium, W.Va.	Urethanes	30	Linde Co.
	Cincinnati, Ohio	Ozone	30	Linde Co.
Total			8,980	

industry. For chemical processing, these requirements will likely include a higher premium on reliability, a lower premium on product flexibility, a smaller on-site need for cylinder oxygen, and less need for peak-demand storage facilities and outside backup.

Table 3 shows the locations and capacities of the oxygen plants in the United States chemical industry as of 1961. Table 4 gives similar data for oxygen plants outside the United States.

In considering European industry, one must bear in mind that, in general, energy consumption is a more important economic consideration in Europe while capital and labor costs are less important than is the case in the United States.

TABLE 4—Types & Locations of Oxygen Plants in Foreign Chemical Industry

Company	Location	Primary Chemical Produced	Short Tons O_2 Per Day	Oxygen Process
West German Oxygen Use Picture				
Gewerkschaft Victor	.....	NH_3	240	L'Air Liquide
Bergbau A G	.....	NH_3	30	Messer
Union Rhein Braunkohlen	Wesseling	NH_3	690	German Linde
Scholven Chemie	Gelsenkirchen	Misc.	120	German Linde
Farbwerke Hoechst	Frankfurt/M	Misc.	710	German Linde
Norddeutsche Chem. Werke	Embsen	Misc.	60	German Linde
Badische Anilin und Soda Fabrik	Ludwigshafen	Misc.	1800	German Linde
Ruhrol	Bottrop	Misc.	100	German Linde
Kraftwerke Mainz-Wiesbaden	Mainz	Town gas	50	German Linde
Knapsack-Griesheim	Knapsack	Misc.	30	German Linde
Ruhrgas	Essen	Town gas	300	German Linde
Braunkohle-Benzin A. G.	Magdeburg	Misc.	90	German Linde
			4220	
Italian Oxygen Use Picture				
Societe Edison	.....	Ammonia and acetylene	400	L'Air Liquide
A.N.I.C.	Ravenna	Acetylene	600	L'Air Liquide
Augusta Petro-chemie	Priolo, Sicily	NH_3	80	Messer
Montecatini	Brindisi	Misc.	300	German Linde
S.I.S.A.S.	Mailand	NH_3	350	German Linde
Montecatini	Ferrara	NH_3 and C_2H_2	365	German Linde
Societe Edison	Priolo, Sicily	NH_3	200	German Linde
S.I.N.C.A.T.	Sicily	NH_3	200	German Linde
ANIC	Ravenna	NH_3 and C_2H_2	900	German Linde
Oronzio de Nora	Figlene-Valdarno	NH_3	350	German Linde
Societe Industrie Chemiche	Venedig	NH_3	170	German Linde
Montecatini	Novara	C_2H_2	200	German Linde
			4115	
United Kingdom Oxygen Use Picture				
I.C.I.	Billingham	NH_3	265	Air Products
Shell Chemical	Shell Haven	NH_3	265	British Oxygen-German Linde
Shell Chemical	Carrington	Ethylene oxide	165	British Oxygen-German Linde
Distillers, Ltd.	Hull	Acetic acid	20	.....
Esso	Fawley	.....	...	Air Products
Scottish Gas Board	Fifeshire	Town gas	220	.....
SE Gas Board	Isle of Grain	Town gas	200	.....
NW Gas Board	Partington	Town gas	65	.....
			1200	
French Oxygen Use Picture				
Office National Industriel de l'Azote	Toulouse	NH_3	80	Air Liquide
Acquitaine Chimie	.....	NH_3	400	Air Liquide
Houilleries de Lorraine	.....	NH_3 and C_2H_2	200	Air Liquide
Kuhlmann	La Madelaine	NH_3	120	Air Liquide
S.G.C.P. (Air Liquide subsid.)	Donges	NH_3	120	Air Liquide
Rhone Poulenc	.....	NH_3	20	Messer
Kuhlmann	Choques	NH_3	20	Messer
ONIA	Toulouse	NH_3	80	Messer
			1040	

Company	Location	Primary Chemical Produced	Short Tons O_2 Per Day	Oxygen Process
Spanish Oxygen Use Picture				
Nitratos de Castilla	.....	NH_3	100	L'Air Liquide
Refineria de Petroleos de Escombreras	.....	NH_3	350	L'Air Liquide
Abonos Sevilla	.....	NH_3	150	L'Air Liquide
ENSIDESA	Aviles	NH_3	135	German Linde
BASF	Puerto Llano	NH_3	300	German Linde
ENCSCLL	Puentes	NH_3	150	German Linde
			1185	
Dutch Oxygen Use Picture				
States Mines	Lutterade	NH_3	80	Air Liquide
Compagnie Neerlandaise de l'Azote	Sluiskil	NH_3	270	German Linde
Mekog N.V.	Ijmuiden	NH_3	200	German Linde
States Mines	Heerlen	NH_3	500	German Linde
			1050	
Belgian Oxygen Use Picture				
Soc Carbochimique	Tertre	NH_3	120	L'Air Liquide
Safea	La Louviere	NH_3	140	German Linde
Union Chimique Belge	Ostend	NH_3	300	German Linde
Soc Carbochimique	Tertre	NH_3	100	German Linde
			660	
Canadian Oxygen Use Picture				
Canadian Industries, Ltd.	.....	NH_3	165	L'Air Liquide
Canadian Chemical Co.	.....	NH_3	150	L'Air Liquide
Brockville Chemicals, Ltd.	Maitland, Ontario	NH_3	180	L'Air Liquide
			495	
South American Oxygen Use Picture				
Nitrocubatao	Brazil	NH_3	90	L'Air Liquide
Fertilizantes Sinteticos	Callao, Peru	NH_3	60	German Linde
Industria Columbiana de Fertilizantes	Bogota, Columbia	NH_3	30	German Linde
			180	
Miscellaneous Oxygen Use Picture				
Fabrika Azotnik Djubriva	Yugoslavia	NH_3	275	L'Air Liquide
Fertilizer & Chemicals, Ltd.	Haifa, Israel	NH_3	45	Messer
Kachsiung Ammonium Sulfate Corp.	Formosa	NH_3	50	Messer
Koppers	Suez	NH_3	240	German Linde
Typpi Oy	Oulu, Findland	NH_3	260	German Linde
Neyveli Lignite Corp.	Neyveli, India	NH_3	375	German Linde
Uhde	Lissabon, Portugal	NH_3	120	German Linde
Greek Gov't.	Ptolemais, Greece	NH_3	400	German Linde
Uhde	Canary Islands	NH_3	80	German Linde
Gov't of South Korea	Naju, South Korea	NH_3	165	German Linde
African Explosives & Chem. Ind.	Johannesburg	NH_3	275	German Linde
Amoniaco Portogues	Estarreja, Portugal	NH_3	30	German Linde
B A S F	Kutahya, Turkey	NH_3	170	German Linde
B A S F	Sindri, India	NH_3	50	German Linde
S A S O L	Coalbrook, S. Africa	Gasoline	1640	German Linde
Gas & Fuel Corp. of Victoria	Morwell, Australia	Town gas	180	German Linde
			4355	

Here's what this series will include

Part 1: Introduction
- Background and growth of the field
- Chemical fundamentals

Part 2: Introduction, Cont'd.
- Economic fundamentals
  1. Alternative routes for oxidation products manufacture
  2. Alternative oxidants
  3. Possible advantages of using oxygen
  4. Possibles disadvantages of using oxygen
  5. Economic factors in evaluating oxygen use

Part 3: Supplying the Oxygen
- Air handling
- Oxygen manufacture
- Oxygen handling
- Oxygen distribution
- Oxygen storage
- Provision of oxygen-enriched air
- Production of ozene

Part 4: Oxidation of paraffin hydrocarbons
- Synthesis gas by partial combustion
  1. Process types
  2. Feed materials
  3. End uses
  4. Specific processes

Part 5: Oxidation of paraffin hydrocarbons, Cont'd.
- Acetylene

Part 6: Oxidation of paraffin hydrocarbons, Cont'd.
- LPG oxidation
  1. Vapor-phase LPG oxidation
  2. Commercial installations

Part 7: Oxidation of paraffin hydrocarbons, Cont'd.
- Autothermic cracking
  1. Ethylene from paraffins
  2. Butadiene from paraffins
  3. Gasoline from heavier hydrocarbons
  4. Hydrogen peroxide by propane oxidation
  5. Hydrogen cyanide manufacture
  6. Oxychlorination using O_2 plus HCl
  7. Formaldehyde from methane
  8. Carbon black
  9. Higher paraffins to carboxylic acids
  10. Higher paraffins to secondary alcohols
  11. Fuel cells
  12. Manufacture of peroxides for catalyst use
  13. Oxygen flame applications

Part 8: Oxidation of olefin hydrocarbons
- Ethylene oxide
- Propylene oxide
- Acrolein
- Acrylonitrile by ammoxidation of propylene
- Maleic anhydride from butenes, butadiene
- Olefins to aldehydes, ketones by Consortium process
- Ethylene by aluminum alkyl route to higher alcohols

Oxidation of cycloparaffin hydrocarbons
- Cyclohexane to adipic acid

Part 9: Oxidation of aromatic hydrocarbons
- Manufacture of polybasic acids and anhydrides
  1. Benzene to maleic and fumaric acids
  2. Nephthalene to phthalic anhydride
  3. Xylenes to phthalic anhydride isophthalic and terephthalic acids
- Dissopropylbenzenes to phthalic acids
  1. Pseudocumene to trimellitic acid
  2. Durene to pyromellitic acid and its anhydride

Part 10: Oxidation of aromatic hydrocarbons, Cont'd.
- Phenol manufacture
- Alkylhydroquinones to hydrogen peroxide
- Aromatics to quinones
- Alkylaromatics to monocarbonyl products
- Ammoxidation to nitriles
- Peroxide manufacture

Part 11: Oxidation of coal and coke
- Coke in catalytic cracking processes
- Coal in gasification for synthesis gas and city gas
  1. Underground gasification
  2. In various types of generators
- Carbide by oxygen blast furnace process
- Oxygen in steel manufacture

Part 12: Oxidation of oxygen compounds
- Isopropanol to acetone plus hydrogen peroxide
- Methanol to formaldehyde
- Ethanol to acetaldehyde
- Acetaldehyde to acetic acid
- Aldehydes to acid anhydrides
- Ethanol directly to acetic acid
- Various aldehydes to maleic acid
- Peracetic acid from acetaldehyde
- Oleic acid to azelaic, pelargonic acids

Oxidation of sulfur compounds
- Gasoline sweetening with oxygen

The future
- Growth in today's chemical process application
- Flame chemistry
- Production of chemicals in motored engines
- Polymers by direct oxidation of monomers

European contacts made during the preparation of this manuscript revealed their thinking that the chemical plant of the not-too-distant future would have an oxygen plant just as it would have a steam plant and that oxygen would be just one more utility on the plant site; this concept permits small processes to draw oxygen at large plant prices.

The world's biggest single oxygen supply setup to chemicals manufacture is at Badische at Ludwigshafen, Germany; the second biggest is at the Sasol plant in the Union of South Africa. Other major oxygen supply points are at Farbwerke Hoechst in Germany and at ANIC at Revenna, Italy. The latter two are comparable to the biggest on-site plants in the United States and the first two are roughly double the size of the biggest on-site plants in the United States chemical industry (except for the Brownsville, Texas, plant which would be the world's biggest if in full scale operation today).

Vapor-Phase Oxidations. The classic work on vapor phase oxidation of organic compounds is the American Chemical Society Monograph by Marek and Hahn.[231] Unfortunately, since it was published in 1932, it is now quite out of date. Some more recent coverage of vapor phase oxidation of hydrocarbon at solid catalytic surfaces has been presented in 1960 by Dixon and Longfield.[128] In the interim, annual reviews of oxidation were published by L. F. Marek between 1948 and 1955 in Industrial & Engineering Chemistry.

Medley and Cooley[242] point out that although the vapor phase oxidation of hydrocarbons has been studied extensively for over 50 years, and although the literature on the subject is enormous, the theory is still incompletely developed.

Liquid-Phase Oxidations. Liquid phase oxidations are defined as processes where the organic starting material, the reaction intermediates, and the final products are present in a liquid system. Either pure oxygen, an oxygen-containing gas, or a chemical oxidant is fed into the liquid phase where reactions occur between the oxidant and the reacting species. Unreacted oxygen, inert gases, and degradation products (such as carbon oxides) pass from the system as a vapor phase.

In general, liquid-phase oxidations are carried out at much lower temperatures than are used in vapor-phase operations. In many cases, liquid-phase oxidations are more selective as well and only one or two major reaction products may be produced in fairly high yields. The ease and extent of such liquid phase oxidations depend on

1. The nature of the material that is oxidized.
2. The concentration of the hydrocarbon.
3. The presence of a catalyst (usually a metal salt).
4. The presence of oxidation inhibitors.
5. Temperature.
6. Oxygen pressure.

Liquid-phase oxidation processes are usually used in the production of chemicals for one or more of the following reasons:

- to limit the duration of operation.
- to control the temperature.
- to limit the amount of oxidation.

In liquid-phase oxidation processes, substitution of oxygen for the air would probably make temperature control and oxidation control more difficult and reaction equipment must be designed accordingly, with particular attention to effective removal of the heat of reaction.

However, substitution of oxygen should reduce the volumes of gaseous reaction products to be handled, should thus reduce entrainment losses, and may also increase reaction rates.

While quantities of oxygen used are small and some additional reaction control problems are introduced, the advantages have outweighed the disadvantages in the case of liquid phase oxidations for the manufacture of acetic acid from acetaldehyde in Germany.

The mechanism of liquid-phase oxidation processes has been reviewed by Twigg of the Distillers Company, Ltd.[369] Interestingly the mechanism of liquid-phase oxidation is now fairly well ascertained, in contrast to the uncertainty regarding vapor-phase mechanisms. In a primary step, hydroperoxides (ROOH) are formed and in a second step these hydroperoxides react to give the final products. Broad coverage of liquid phase oxidation has been afforded on an annual basis since 1958 by Toland of California Research Corp. in Industrial and Engineering Chemistry. Other reviews include those by Frank[158] and a book by Emanuel.[143]

Chemical fundamentals

THE NATURE OF OXIDATION REACTIONS

Oxidation reactions cover a wide spectrum of chemical processes, ranging from mild alteration of a hydrocarbon structure (by atmospheric oxygen at room or moderate temperatures) to partial oxidations to alcohols, aldehydes, etc. through "cool flame" reactions to severe degradative oxidations and finally to complete combustion to carbon dioxide and water (in the presence or absence of visible flame).

Waters[286] has used the term "autoxidation" to describe "oxidations which can be brought about by oxygen gas at normal temperatures without the intervention of a visible flame or an electric spark." This covers the production and decomposition of hydroperoxides which lead to autoxidation. The term has been widely applied to include "cool-flame" -type reactions which are outside the scope of the original definition and indeed to include most processes of interest today for producing commer-

cially-valuable oxygenated products from aromatic and aliphatic hydrocarbons.

Induction periods are characteristic of both liquid-phase and vapor-phase oxidation reactions. Such an induction period may be shortened by purification processes, by an increase in temperature, or by the addition of initiators.

THERMODYNAMICS

As pointed out by Marek,[230] the important thermochemical quantity in oxidation reactions is the heat evolved. Generally, equilibria are favorable and the practical operating problems largely involve the removal of heat at the desired reaction temperature level and the limitation of oxidation to the desired product by avoidance of complete combustion. Table 5 gives heats of reaction for some typical oxidation reactions.

Temperature Control. The reader is referred to a review on exothermic reaction techniques[342] by Sittig. The taming of dangerous chemical reactions has more recently been discussed by Boynton, Nichols and Spurlen.[88]

TABLE 5—Heat Evolved in Some Typical Oxidation Reactions at Constant Pressure[230]

		Kcal/mole
CH_4	$\longrightarrow CH_2O$ (g) + H_2O (g)	67.61
	$\longrightarrow CO + 2H_2$	8.53
	$\longrightarrow CO_2 + 2H_2O$ (g)	191.76
C_2H_6	$\longrightarrow CH_3CHO$ (g) + H_2O (g)	77.32
	$\longrightarrow CH_3COOH$ (l)	96.16
	$\longrightarrow C_2H_4 + H_2O$ (g)	25.07
	$\longrightarrow 2CO_2 + 3H_2O$ (g)	341.26
C_2H_4	$\longrightarrow C_2H_4O$	24.69
	$\longrightarrow CH_3CHO$	52.26
	$\longrightarrow 2CO_2 + 2H_2O$ (g)	323.94

TABLE 6—Explosive Limits of Some Hydrocarbons

Hydrocarbon	Vol. % In Air		Vol. % In Oxygen	
	Lower	Upper	Lower	Upper
Methane	5	15	5	59
Ethane	3	15	3	66
Propane	2	9	..	..
Butane	2	9	..	..
Pentane	1	8	..	..
Ethylene	3	29	3	80
Propylene	2	11	2	53
Butylene	2	9	..	..
Butadiene	2	12	..	..
Benzene	1	8	..	..
Toluene	1	7	..	..
Xylene	1	6	..	..

TABLE 7—Explosive Limits of Some Various Chemicals

Material	Vol. % In Air		Vol. % In Oxygen	
	Lower	Upper	Lower	Upper
Hydrogen	4	75	4	94
Ammonia	16	27	15	79

TABLE 8—Summary of Catalysts Used in Oxidation Processes

Reactant	Principal Oxidation Product (Other Than CO_2)	Main Metallic Catalyst Constituent
Olefins	Aldehydes	Cu, Pd
Olefins	Olefin oxides	Ag
Hydrocarbons + Ammonia	HCN, nitriles	Pt, Mo
CH_3OH	HCHO	Ag, Cu
Butane	Acetic acid	Co
Benzene	Maleic anhydride	V
Naphthalene, o-xylene	Phthalic anhydride	V
Xylenes	Phthalic acids	Mn, Co
Acetaldehyde	Acetic acid	Mn

STOICHIOMETRY

As one goes from a pure hydrocarbon through various mixtures of increasing oxygen content, one passes through a series of ranges—

- a range in which partial oxidation can be accomplished by the use of catalysts or elevated temperatures
- an explosive range above a lower explosive limit and below an upper explosive limit
- an oxygen-rich range which is not explosive and which is usually uneconomic for the conduct of commercial oxidation reactions

Volumetric and thermal data for combustion with oxygen in contrast to air have been derived from stoichiometric relations and reported for various fuels by Fehling.[153]

Explosive Limits. Data on the explosive limits of various hydrocarbons in oxygen and air have been published by Yeaw.[196] Data on limits in oxygen are not plentiful, however, as evidenced from inspection of such recent and comprehensive works as that by Penner and Mullins.[277] It can be generalized that the lower limit in oxygen is essentially the same as that in air and that the upper limit is much higher in pure oxygen.

It should be emphasized that flammability limits or explosive limits are approximate numbers which vary with temperature and with the type of ignition source. Thus, the values in Table 6 can serve as a guide but should be used with caution. In process design, values specific to the particular process conditions should be determined—not only for safety reasons but for economic reasons since close control may improve product quality and improve the operating cost picture.

Available data on the explosive limits of some hydrocarbons are given in Table 6 and data on materials of related interest in oxidation reactions is given in Table 7.

KINETICS

Catalysts in oxidation reactions generally serve a directive rather than an overall accelerating function.

Catalysts. The mechanism of catalytic oxidation, along with a discussion of the electronic properties of oxidation catalysts and of the correlation of catalyst properties and catalyst performance has been outlined by Dixon and Longfield.[128]

The selection of catalysts for oxidation processes has been discussed by Tarama.[354] Table 8 summarizes a number of the types of catalysts used in various typical oxidation processes.

Catalysts, Halogen-Containing. The low-temperature oxidation of paraffin hydrocarbons is catalyzed by a good hydrogen donor such as hydrogen bromide. In the presence of HBr, the oxidation chains are modified so that peroxy radicals, instead of degrading, are converted

to hydroperoxides and thence into stable end products without carbon chain rupture, as described by Vaughan and Rust.[376] Further, as pointed out by Raley, Rust and Vaughan,[289] these reactions utilizing hydrogen bromide also in some cases lead to products not previously derived in quantity from reactions with oxygen. High yields of relatively simple mixtures are obtained at temperatures far below those usually encountered in hydrocarbon oxidations. Thus, isobutane can be converted to tert-butyl hydroperoxide in 75 percent yield at 160° C; propane to acetone in 75 percent yield at 190° C.

As Marek has summarized,[228] the hydrogen bromide catalyzed oxidation of hydrocarbons gives the following results:

1. Ethane goes mainly to acetic acid.

2. Straight-chain paraffins above ethane go mainly to ketones.

3. Branched-chain paraffins go chiefly to stable peroxides.

4. The character of the product is determined by the most reactive C-H bond in the molecule with the reactivity: tertiary > secondary > primary.

5. The reactions are characterized by a low degree of C-C splitting, low reaction temperatures and high yields and conversions.

6. Increased reaction pressure lessens wall effects, increases product yields, retards side reactions, and reduces the proportions of catalyst required.

Catalysts, Oxynitrogen Compounds. Introduction of up to 2 mole percent of nitroalkanes in the homogeneous oxidation of aromatics such as cumene exert a profound effect according to Dixon and Longfield.[128] Similarly isoamyl nitrite, nitromethane and aniline all gave yield improvements in the manufacture of phthalic anhydride from orthoxylene. The effects of these various additives may all be attributed to the formation of nitric oxide which is known to be of considerable influence on homogeneous gas-phase oxidations, even in trace amounts.

Nitric acid was studied as a catalyst in the vapor-phase oxidation of aliphatic kerosene fractions by Parks and Story.[272]

Catalysts, Silver. Silver catalysts have been used in a variety of commercially important oxidation reactions including

- methanol to formaldehyde
- ethylene to ethylene oxide

However, propylene is converted almost completely to carbon dioxide rather than to acrolein when a silver catalyst is used as noted by Andrianova and Roginskii.[6] Similarly, as Bretton, Wan and Dodge have reported,[90] silver and silver oxide catalysts gave no intermediate products of interest but only CO_2 and water in the oxidation of four-carbon hydrocarbons.

Catalysts, Heavy Metal Organic Acid Salts. Manganese acetate has long been used as a catalyst in the liquid-phase oxidation of acetaldehyde to acetic acid. More recently, heavy metal organic acid salts have come into prominence in the liquid-phase oxidation of xylenes to phthalic acids.

Catalysts, Vanadium. Oxidations carried out by means of vanadium oxide catalysts have been reviewed by Mars and Van Krevelen.[233] These authors point out that the over-all reaction may be viewed as an oxidation-reduction process; the substance to be oxidized reduces the catalyst, which is then re-oxidized by oxygen.

Catalysts, Copper-Containing. The use of copper-containing catalysts in oxidation reactions has been discussed by Marek.[230] A major area of commercially-important use of copper catalysts has been in the oxidation of propylene to acrolein; another has been in the oxidation of methanol to formaldehyde.

Catalysts, Miscellaneous. Boric acid prevents inhibition of vapor phase oxidation of benzene to phenol by inert packing according to Moyer.[254] It is probable that the boric oxide prevents breaking of free-radical chains on the packing surface and thus facilitates homogeneous oxidation rather than itself acting as a positive catalyst.

Lead tetraethyl has been studied as a homogeneous catalyst for the vapor-phase oxidation of kerosene fractions by Parks and Story.[272]

Plumbate catalysts catalyze the oxidation of isobutane to hydroxyisobutyric acid (which can be dehydrated to methacrylic acid) as described by Vogl.[378]

Inhibitors. Although oxidation inhibitors are more commonly thought of in the prevention of deterioration of oils, etc., they may have a function in commercial hydrocarbon oxidation reactions. Thus, ethylene dichloride is used as an "anticatalyst" to repress the complete oxidation of ethylene to carbon dioxide and water in ethylene oxide manufacture.

Key Words for Indexing

Acetaldehyde
Acetic Acid
Acetone
Acetylene
Acrolein
Acrylonitrile
Air
Alcohols
Ammonia
Benzoic Acid
Butadiene
Carboxylic Acids
Carbon Black
Catalysts
Coal Gasification
Economics
Ethylene
Ethylene Oxide
Formaldehyde
Fumaric Acid
Gasification
Hydrocarbons
Hydrogen Cyanide
Hydrogen Peroxide
Maleic Anyhydride
Methanol
Oxidation
Oxygen
Phenol
Phthalic Anhydride
Propylene Oxide
Synthesis Gas

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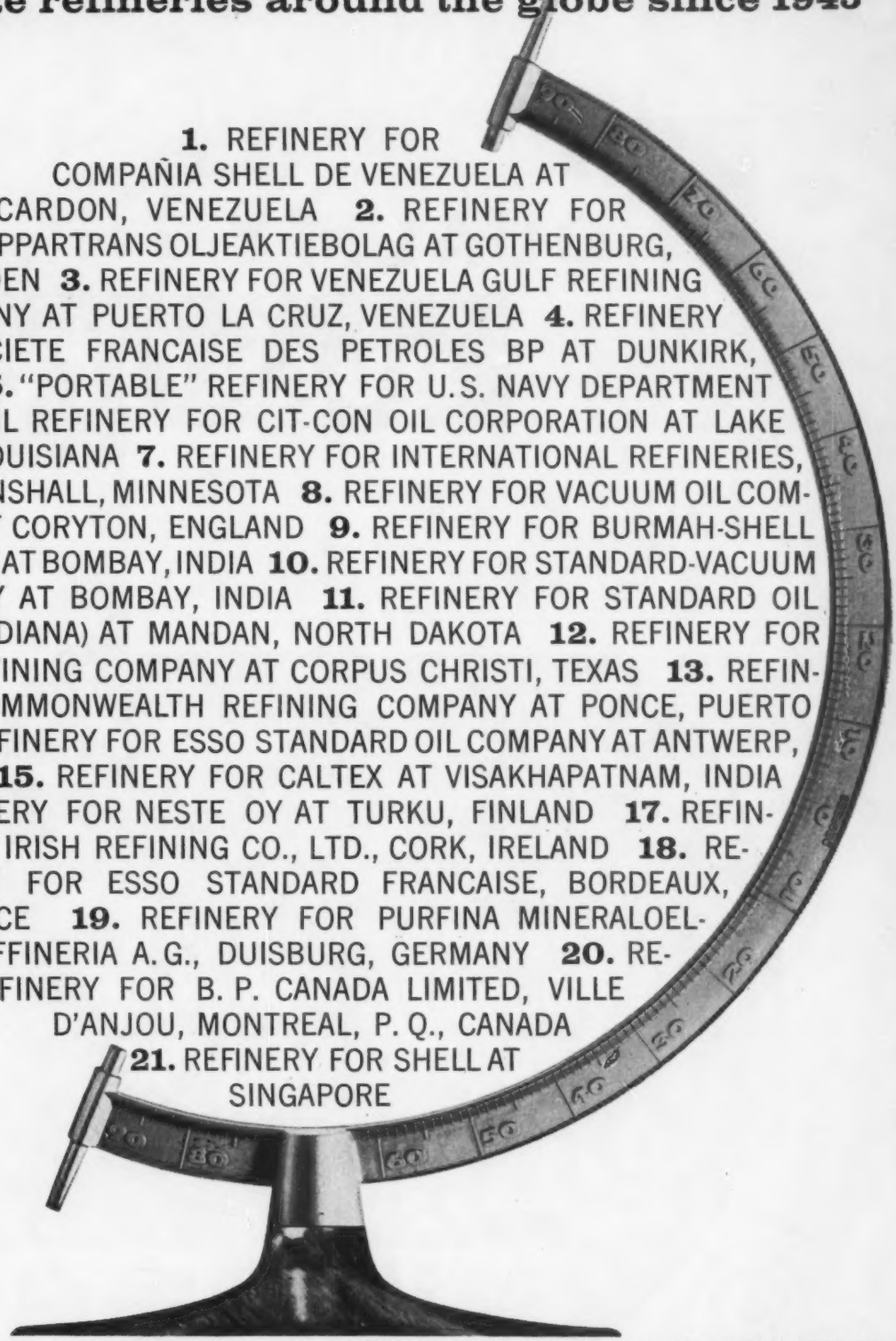

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PART 2

MANAGEMENT DEVELOPMENT:
PAST, PRESENT, FUTURE

A Look at Today's Management Training

Charles H. Vervalin
Hydrocarbon Processing & Petroleum Refiner Staff

Management development has come a long way in the last 10 years. Few large companies remain in which there are not at least some earmarks of formally preparing men for future supervisory positions, and further training those who hold them. As was pointed out in Part I, both formal and informal systems of supervisory training florished throughout the '50s, with the strongest emphasis on human relations and communications problems.

In 1954 the American Management Association made a study of management development activities of American business firms. A sample of 5,250, or about 25 percent of all then existing corporations with 250 or more employes was selected.

Responses came from 1,954 firms and interviews were held with an additional 530. Respondents reported some kind of management development plan in 30 percent of the cases. Of firms interviewed directly, 48 percent had plans. Reported activities varied in length of time they had been conducted to from six months to more than 10 years, but a typical group was between two and three years.

The study showed that larger firms led the field in organized development plans. About 25 percent of the plans in operation were comprehensive—that is, covered all management levels without limitation. The rest were restricted with regard to subject matter, functional area covered, or level of management. For example, 25 percent of all restricted plans were operated only for first-line supervisors and foremen.

In the seven years that have elapsed since this AMA survey, the picture is even better, although the "comprehensive" program (with various combinations of classroom training, seminars, job rotation, and university development courses, etc.) is still centered primarily in the larger corporations with several thousand employes.

Types of Training. Today's management development consists of eight general categories, as follows:

(1) **Executive Development**
(2) **Supervisory Development**
(3) **Management Trainee Programs**
(4) **General Education**
(5) **Breadth and Change Training**
(6) **Technical Personnel Development**
(7) **Self-Development Programs**
(8) **Human Relations**

Naturally, some of these categories overlap, and few companies feature a well rounded plan including all of them. In those that contain several of the categories there are varying combinations and degrees of emphasis. Techniques are variable too. For example, Company A's executive development plan may consist solely of shipping all it's senior administrative officers to Harvard, Arden House, or some other location for a course in executive leadership, while Company B conducts its own in-company program. However, most of the major oil and chemical companies do both, and there is a growing trend in the HPI to send senior and junior executives alike "back to the campus" for a short-course seminar or graduate degree.

Now let's categorically analyse the eight types of programs to see how each fits into today's management training picture.

EXECUTIVE DEVELOPMENT

The word *executive* as used here refers to the top men in any company who make and administer policy. They are the presidents, VPs, plant managers and superintend-

ents, divisional directors, etc. They are literally the supervisors of supervisors.

Content. Executive development is the planned improvement of high-level managers in those understandings, attitudes, and activities that enter into or influence their job and job relations. There is no "typical" executive development program, but a great many center attention on the following four needs of every top-echelon manager.

- More self understanding and understanding of others.
- Knowledge of the economic and social forces at work in business and the nation, how industry influences these forces, and how these forces in turn react upon industry.
- How to apply scientific and engineering management.
- Technical knowhow in the various specialties—engineering, research, sales, transportation, etc.

Method. Executive development is undertaken individually and in groups and is handled both inside and outside the company. The following outline will give you the big picture.

I. Techniques best for on-the-job and in-company training
  1. Individual methods
    (a) Job progression
    (b) Job rotation
    (c) Understudies
    (d) Fill-ins during leave or vacation
    (e) Coaching and counseling
    (f) Guided experience
    (g) Consultants
  2. Group methods
    (a) Committees
    (b) Consultants
    (c) Conferences

II. Techniques for in-company and outside training.
  1. Individual methods
    (a) Psychological evaluation
    (b) Counseling
  2. Group methods
    (a) Lectures
    (b) Forums
    (c) Panels
    (d) Syndicates

III. Courses, seminars, conferences, schools, etc.
    (a) University conferences
    (b) Case studies, role playing and decision-making games
    (c) Debates
    (d) Workshops
    (e) Sensitivity training (group dynamics)
    (f) Courses toward graduate degree

SUPERVISORY DEVELOPMENT

Content. Usually, supervisory development programs are available for all supervisors, throughout the HPI operating companies. As with executive development, emphasis and content is highly variable, but a typical plan involves the following basic areas.

- **Personal Development.** It involves the need for the supervisor to constantly be going through a process of self evaluation with respect to his thinking, communicativeness, and ability to organize.
- **Human Relations.** Development of an understanding of human relationships with subordinates, superiors, and other business associates, with emphasis on communications and morale building.
- **Economics.** Development of a thorough understanding of how his job relates to economic objectives of his company, the community and the nation.
- **Company Operations.** How the company is organized, how it markets and distributes its products, and how policy is developed and carried out.
- **Technical Operations.** Development of supervisor's technical knowhow affecting operation of his department, division, and company.

Method. There are a number of other ways in which supervisors are currently being developed. In addition to formal in-company courses, the following methods are being used throughout industry.

- **Guided experience**
- **Correspondence courses**
- **Technical and management conferences**
- **Evening courses, both academic and non-academic**
- **Plant visits for observation and discussion**
- **Trade magazines**
- **Professional society membership**
- **Psychological consultants**
- **Staff meetings and conferences**
- **Job rotation**
- **Subbing for the boss when he's on vacation, etc.**
- **Committee assignments**
- **Supervisors' clubs**
- **Counseling and coaching by superiors**
- **Merit rating and performance review**
- **Service in community organizations**

One problem in current supervisory training practice is that few companies formulate long-range objectives and carry out plants to meet them. Most firms work from yearly plans dictated by immediate needs. Many companies that have long-range programs assign them to a training director or committee for development.

MANAGEMENT TRAINEE PROGRAMS

Method. The management trainee program is a prelude to a more comprehensive management development setup. Candidates are usually fresh out of college or have their degree but little work experience. This type of plan, directed at employes in training for management positions, is usually followed by or merges with the general management program previously discussed.

Content. A typical management trainee course would include the following.

- Orientation to company policies, organization, products, philosophy and personnel. There are meetings with key executives, plant tours, etc.
- Job rotation experiences, in which the employe handles a series of jobs throughout the company so he can learn the interrelationship of key functions and evaluate the company's operation.
- Specialized training after the two above steps. The employe is assigned to the department where he will work and is given intensive specialized training in most areas of this department.

GENERAL EDUCATION

There is a great deal of current emphasis on post graduate academic training. This is true in all fields, but is especially true in the natural sciences and engineering. For example, a recent survey by the Engineering Manpower Commission reveals that 23.7 percent of current engineering grads are staying in school for further studies, either at night while holding a full time job, or in residence at school.

A number of schools offer a program designed specifically for the engineering or science grad, which leads to the M.B.A. degree. This reveals two important points: (1) more engineers and scientists are going into administration and supervision, and (2) they need advanced study in management and business techniques they missed in undergraduate engineering studies. Some schools offer short courses incorporating most of the subject matter leading to the M.B.A. degree. For example, Harvard's 13-week executive development program involves such a plan.

Technical and administrative personnel are being encouraged to study in the liberal arts field also—especially such courses as speech, writing, political science, psychology and sociology, and other courses dealing with communications and socio-economic problems.

BREADTH-AND-CHANGE TRAINING

Content. This important aspect of management development is a sort of "mind stretching" technique designed to change the thinking habits of older men, usually well into administration. Programs currently offered in this aspect of development focus on the reluctance to change characteristic of us all—but even moreso in the older manager. There is a strong trend throughout industry to encourage top-executive development of creative thinking and flexibility.

Method. Here's how a number of companies in the HPI are handling this problem:

- Executives are being assigned to committees and decision-making groups that bring them in contact with new ideas.
- Attention is being focused on the inevitability of change through recent restructuring and "shakeups" of many large corperations, especially in the oil and hydrocarbon processing industry. Many HPI companies have programs to help their supervisors make the necessary transition to a sometimes entirely foreign situation.
- Many companies are seeing that conservative executives get projects that will pull them into new situations.
- Many firms using Breadth-Change training outwardly reward men who show promise of adaptability, openmindedness and creativity.
- Most firms send men to other plants, professional society meetings, and conventions for ideas.
- Some companies counsel executives with regard to the dynamics of change, and some have formal courses on this morale-oriented problem.
- Attention is being given to the executive audit, which helps the manager understand his fear of new things and ideas.

These methods, when combined with a continuing development program, have been showing some excellent results throughout industry.

TECHNICAL PERSONNEL DEVELOPMENT

It is generally conceded that a surprisingly large number of engineers and scientific personnel have no desire to go into upper management. There are many reasons for this, depending on the individual. But perhaps the most prominent one is the tendency for many technical people to be research oriented—to grab hold of a specialty and develop it to their maximum potential. Such men have little patience with the subjective, socio-economic orientation of many business policies and decisions.

Nevertheless, the growing need for technically trained managers shows no signs of slowing down. Assuming that our industrial economy continues to grow at a reasonably fast clip, practically all young engineers will eventually end up in a supervisory or managerial job, be it technical or purely administrative.

Most of the major HPI companies have grasped this reality, and offer training courses orienting engineers and scientists to the different functions of business.

Content. Following are some of the current techniques used to expose technical people to over-all management problems.

- Have them serve on committees where they can work and cooperate with other divisions.
- Multiple management organization under which they see the full scope of the business as well as services rendered and problems faced by other functions.
- Interdepartmental rotation of engineers (such as from R & E to design, to maintenance, etc.)
- Training programs that employ case methods, workshops, role playing, decision-making games, etc.

SELF-DEVELOPMENT PROGRAMS

Content. More and more companies are taking the initiative in encouraging self development by managers and potential managers. The big advantage seems to be that through the various means for personal development, men learn conscientious self reliance. Some companies have automatic merit salary increases when employes finish advanced formal academic training, such as completion of a correspondence course or receiving an advanced college degree. An ever increasing number of companies pay for books and tuition for advanced training. Many others offer immediate or early promotions to men who complete job-oriented studies. This accomplishes the dual purpose of building morale and stimulating further incentive to develop management skills.

Method. In most firms where self development studies are encouraged, executive audits and counseling between the subordinate and his superiors offer a good chance to guide the student so his course benefits him and the company. Some larger companies have one or more men in the Training Department qualified in vocational or educational guidance, and who specialize in this work.

HUMAN RELATIONS

In Part I we discussed the development of human relations in the '50s. The human relations field is still, by far, the most heavily emphasized concept in management development. However, it has undergone considerable evolution since its inception.

As Warren G. Bennis points out in "Revisionist Theory of Leadership," (*Howard Business Review*, January 1961, page 24) "Research findings . . . have challenged some of the basic assumptions of the human relations model—for example, whether attention to group process factors leads to greater efficiency of group operations, whether the leader who attempts to get close to the men is a more efficient leader, and whether the leader can or should avoid hostile and aggressive attitudes directed toward him by his men. . . . The Utopian wish to escape conflict, to avoid tough decisions, to create 'the happy family,' and to stress group and interpersonal factors, tinctured the writings of early human relations students. Yet, this was an indispensable antidote, a required emphasis, given the personal models of the classical era . . . Now the revisionists are concerned with external, economic factors—with productivity, formal status, and so on—but not to the exclusion of the human elements that the traditional theorists neglected."

If human relations development has done anything significant in management and personnel development, it has been to point up the variability of human nature and group relationships, and how these relationships can affect the productivity—even survival—of a company. Involved here are the same factors that have thus far kept psychology from becoming a "pure" science: variability between people in terms of native intelligence, genetical, chemical and physical differences and the millions of differences in each person's environment and experience that make him a unique entity.

Nevertheless, Human Relations, and the many training programs that evolved from the early Human Relations model, is still with us as the key concept upon which nearly all development programs hinge. Like the psychologist, proponents of human relations programs are still groping, searching, analysing, the corperate structure and the *people* that make it up—hoping to find the right formula to satisfy the need for ideal relationships between people. Training and development personnel know better than anyone what subjective criteria they are working with.

In studying the subjective area of Human Relations, constant trial-and-error research holds the greatest promise of finding the "ideal" training approach. This quest has been the catalyst for the many "fads" that have characterized attempts at management development in the past. Many of these experimental programs were planted along with others in the garden of Human Relations, bloomed, flourished for awhile, and died.

Content. Human Relations in today's industry still turns about a nucleus of the following hard-core thesis:

- People should fully understand themselves—their motivations, needs, desires, habits, philosophy of life, etc. This introspective self-analysis should ideally lead to a clearer understanding of others.
- People should cultivate an attitude of acceptance and respect toward others. They must learn to distinguish between people and ideas, and to challenge ideas without threatening people.
- People should have a philosophy of life that fits a constantly changing world, and learn to adjust to these changes without sacrificing "self."
- People should learn to react to the causes of behavior rather than the symptoms.
- People should develop their personalities and potentials for creativity to the maximum.
- People should understand and respect the values that bind men together, with the goal of giving order and meaning to their lives.
- People should understand their society and take part in its religious, economic and political life.

The problem is one having a development program that motivates people to orient these goals to business life. But the management development hat is in the ring, and it sports a badge of Human Relations.

OUT-OF-COMPANY PROGRAMS

Many colleges and universities offer development programs to supplement in-company training or, in cases where a company has no formal in-company program, provide broad education in all aspects of management.

More than 4,000 executives spend an average of six weeks at "outside" in-residence executive development programs each year, at a tuition cost of at least $8 million. More than 3,300 of these attend a hard core of 51 programs conducted by universities or private groups such as American Management Association. Of these, about 25 percent attend the AMA four-week program, and an additional ten percent go to Harvard for the 13-week class.

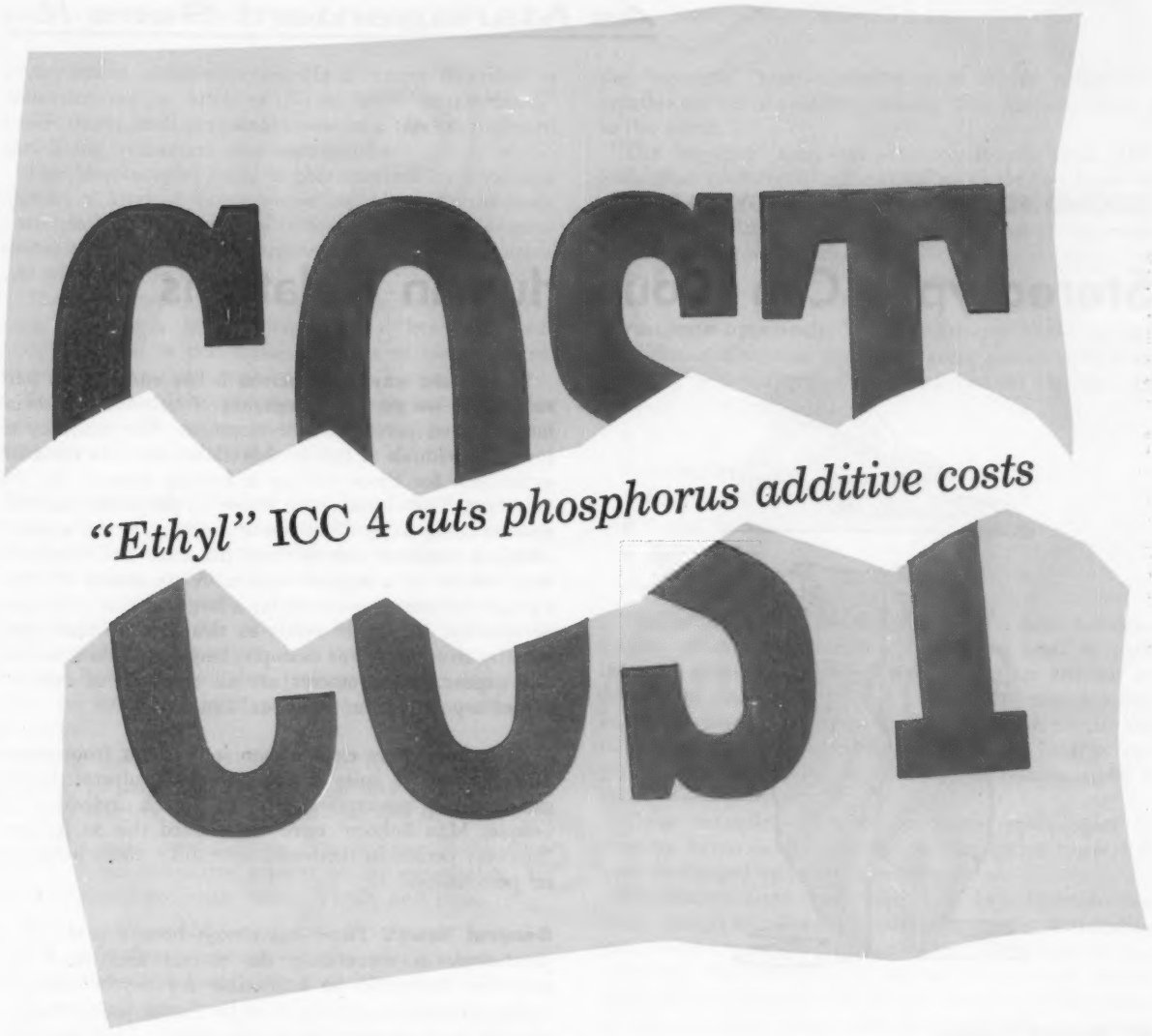
About 75 percent of the 3,300 executives attend 85 percent of the courses which run from two to six weeks. About 15 percent attend 25 percent of the programs running from two to three weeks. The remaining 25 percent of the participants attend 15 percent of the programs which run for more than six weeks.

All of these programs are concerned with the broad aspects of management, they are not confined to a specific function, such as marketing. All of them deal with the problems of industry generally and require at least two weeks of in-residence attendance. A comprehensive report on contents of these 51 key programs ("1961 Executive Development Programs," by G. W. Bricker, Jr., and W. A. Hertan), is available from Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

SUPPLEMENTARY READING LIST

There is a vast amount of literature available on the general subject of management development, all of which we obviously could not list here. But most publishing houses have booklets or brochures which they are glad to remit free, on request. If you or your company library have back issues of PETROLEUM REFINER, you'll find that most of them since 1958 have one or more articles touching on subjects being covered in management development. These articles always appear in the "As Management Sees It" section. Another excellent reference: "Training in Organization: An Annotated Bibliography," New York School of Industrial Relations, Cornell University, 50 cents.

Next month, in Part III, "A Look at Tomorrow's Management Training," we'll take a hard look at what's in store for management development in the '60s.



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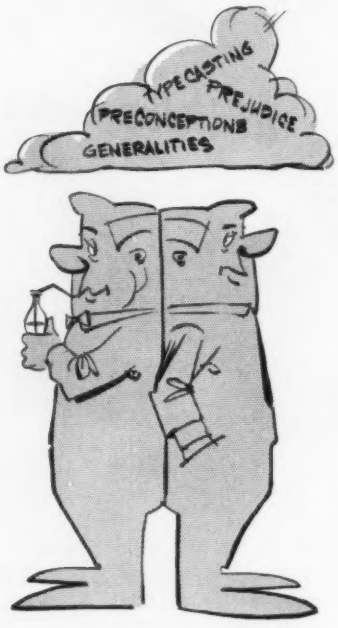
JUDGING PEOPLE BY PSYCHOLOGY—PART 2

Stereotypes Can Cloud Human Relations



Dr. Richard I. Evans
University of Houston, Houston

In recent years business and industry in the United States have strongly emphasized human relations. Many attempts have been made to train administrators to cope with human relations problems through such methods as "sensitivity training." Often, such training ignores the global aspects of human behavior, selecting several small aspects of the problem for emphasis. Many times, the over-all situation is ignored.

As we view this problem, we should keep in mind three principles involved in understanding the individual, once articulated by Henry Murray,[2] and here presented with a somewhat different exposition:

1. In some ways each person is like *every* other person. Example: hunger, thirst, sex, and avoidance of pain. With increasing psychological maturity, these universal aspects of the individual's motivation become increasingly less important as a means of understanding his behavior. The individual moves from immature primary *physiological*-drive responsiveness to an increasingly mature responsiveness to secondary and tertiary *social* drives.

2. In some ways each person is like *some* other persons. Here we see the importance of cultural and social influences on personality development. The tendency to judge individuals at this level is illustrated by a common experience for those visiting a foreign country for the first time. The visitor seems to see all people in that culture as being alike. Here one is reacting to the ways in which a common culture may influence individuals in that culture in a similar fashion. A composite of these cultural influences accounts for a large portion of human personality. Kardiner[2] refers to this as the "basic personality structure." For example, language, values, mores, and expressive movements are all examples of culture-bound aspects of the individual's make-up.

3. In some way each person is different from *every* other person. In spite of universal and cultural dimensions of the personality structure, each individual is unique. Max Schoen[3] once emphasized this as follows: "If every person in the world were alike, there would be no personality."

General 'laws'. There has always been a problem in psychology in reconciling the second and third approaches. It would be impossible for psychologists to study every single individual in his "utter uniqueness"—arriving at a complete set of principles to help him fully understand and predict the behavior of every human under all conditions. So, the psychologist seeks general laws which will at least apply to *most* people in *most* situations.

For example, the average psychological test is developed on the basis of responses of a group of individuals to test items. The ultimate goal: to allow each individual tested to be evaluated in terms of group performance. As a matter of fact, most psychologists consider understanding the individual in the unique sense as more art than science.

In terms of the level of understanding referred to in No. 2, above (in some way each individual is like some other individuals) the history of psychology reveals development of many so-called *type theories* of personality. For example, some have attempted to type personality on the basis of body build. Currently, the most widely discussed theory of this sort is the one developed by William Sheldon.[4]

Sheldon's method. Sheldon described three principal body builds: the Endomorph, the Mesomorph, and the Ectomorph. The Endomorph is characterized as having

a very broad, obese structure. He is further described as demonstrating a kind of "inner-body centeredness," which shows itself personality-wise in a tendency toward easy living, relaxation, and socialability.

The Mesomorph's build is characterized by bone and muscle, a kind of "strong-man build," or "outer-body centeredness." Such an individual purportedly demonstrates such personality characteristics as a love of power and willingness to take risks.

The Ectomorph, a prototype which involves a thin, long, and fragile body build, exhibits "brain-centeredness," revealed in personality patterns of emotional restraint, inhibition, and withdrawal.

Sheldon has developed a body measurement index which shows the degree to which these type-tendencies are present in an individual.

Jung's approach. The late Carl Jung[5] developed what was to become a widely applied typology when he introduced the concepts of extroversion (referring to a tendency to relate outside the individual to the world of reality) and introversion (a tendency to relate internally and subjectively to the phantasy life of the individual). Relating these introversion and extroversion tendencies to four functions—*thinking, feeling, sensation* and *intuition*—he developed eight principal types of personality patterns:

1. The *extroverted-thinking* type is characterized by relating to the outside world in a very concrete sense. He may often be too logical and may also be rigid.

2. The *introverted-thinking* type is more likely to relate to inner subjective aspects of the personality. He may be concerned with theory, ideals, and ideas.

3. The *extroverted-feeling* type, a pattern Jung believed more often present in women, reflects a keen sensitivity to the world about oneself, and by over-conformity.

4. The *introverted-feeling* type relates to his inner-ego needs, as he lives in a world of daydreams.

5. The *extroverted-sensation* type, as Jung described him, tends to take the world of reality as he finds it. He pursues pleasure above all else.

6. The *introverted-sensation* type is more preoccupied with internal sensations of the body.

7. The *extroverted-intuition* type is guided by needs to speculate and play hunches.

8. The *introverted-intuition* type is likely to be preoccupied with his own imagery—sometimes in the form of clairvoyance. He may, in fact, be a mystic.

Rank's approach. Within his theory of personality, the late Otto Rank[6] spoke of three fundamental types: the "average," "neurotic," and "creative" man. Rank felt that the "average" man represents most individuals who, as he views them, are pretty much controlled by their own unconscious and the pressures of the outer world. In short, he never frees his own "will," as Rank referred to the human ego. He becomes an overconformist.

The "neurotic" man rebels in attempting to free his "will"—contrives to behave inconsistently with the demands of conformist pressures of society. Rank felt that the "neurotic" man dissipates most of his potentially creative energy in rebelling, leaving little for contributing to the world.

The "creative" man was obviously Rank's ideal. This individual conformed sufficiently to society to learn to understand and communicate. But he freed his "will," as a free individual agent, enough to transcend the more stifling conformist controls and contribute creatively to society.

Spranger's approach. The late Edward Spranger,[7] on the basis of elaborate studies of great historical figures, felt that personality could be classified on the basis of six basic value types:

- Political
- Economic
- Religious
- Social
- Theoretical
- Aesthetic.

The *political* type is characterized by a need for controlling others; the *economic* type by a need to gain financial strength; the *religious* type by an attempt to develop a "oneness" with a "higher" transcendental force; the *social* type by strong humanitarian needs; the *theoretical* type by a need to create on the basis of objective inquiry; and the *aesthetic* type is dominated by a love of art and beauty.

These examples of efforts of some psychologists to describe behavior by developing descriptive types has been challenged by many investigators.

Challengers argue that individuals do not fit into discrete categories. For example, even early personality tests based on such contributions as Jung's traits of extroversion and introversion indicated that most individuals did not actually fall in one category or the other. In fact, most individuals were neither clearly extroverted nor introverted. Similar doubt has been expressed of most of the other typologies.

Criticisms of their work are often based on the assumption that they implied *all* people could be placed in their type categories. But most psychologists who developed "type theories" of personality never intended to imply that every individual *clearly* fell into any of the type categories. They suggested the categories merely as points of departure. For example, in chatting about this point with Dr. Jung in Zurich a few years ago, I found him most upset by what he referred to as the naive tendency of Americans to use his introversion-extroversion categories too literally to describe individuals.

Classifications. Even in the area of abnormal psychology, the classification of mental disorders, used to place patients in one category or another on the basis of a diagnosis of a suspected personality disorder, is rapidly being replaced. Instead, clinical psychologists and psychiatrists now tend to look at the patient as a distinct individual, the understanding of whom could be seriously clouded by placing him too arbitrarily in a *category* of mental disorder.

It is very surprising to those of us who teach psychol-

ogy in universities to discover the number of instances in which students and even professional colleagues indicate a questionable use of mental illness classifications. Too often, too much concern is registered with respect to classifying a mentally disturbed person in terms of, for example, whether he is this kind of schizophrenic or that kind, suggesting a blindness to the fact that simply putting such a "label" on the mentally ill person *in itself* does not solve the more important problem of helping him.

Typecasting. It is not surprising, therefore, that the layman makes similar attempts to "typecast" people in everyday life. Like the psychologist, confronted with the problem of understanding and predicting human behavior, they try to employ a level of understanding the individual which involves some form of over-simplified classification. But the layman's approach is generally less objective than the psychologist's. The layman often makes a *final* judgment in his understanding of an individual in terms of what he believes to be the characteristics of a group to which this individual belongs. This tendency toward pre-judgment, or as Walter Lippmann[8] describes this phenomenon, "pictures in our heads," is often called stereotyping.

The late Else Frenkel-Brunswik[9] also described such stereotyping as an "intolerance of ambiguity." She believed it is based on an influence built right into the innate organizing tendencies of the brain—and reinforced by the culture in which we live. In other words, we are, from the very beginning, frustrated in our attempts to understand the complex world about us. So we hope that understanding can be attained by generalizing the few concepts that we learn at first to everything in sight.

To illustrate, as infants we learn that a certain pattern of light which keeps coming around to give us milk and comfort is "Mama." It is not surprising that we mistakenly, at first, refer to almost anyone who gives us milk and comfort as "Mama." Although we gradually establish many concepts, we often continue to apply them in a naive, inappropriate manner. This avoids the psychological tension resulting from being confronted with something ambiguous—something we don't really understand.

In the area of human relations we thus try to set up "pigeonholes" in which we can place all people we contact. This explains why classifications such as Jung's extrovert and introvert types are so widely used by the layman.

'General Semantics' movement. The "general semantics" movement, started by the late Alfred Korzybski,[10] attempted to show us the dangers to adequate communication of the over-simplified labeling tendency in our language structure. Strangely enough, supporters of the general semantics movement, and psychologists such as the late Kurt Lewin,[11] blamed Aristotle's brilliant, highly influential attempt to classify objects in the world as a means of better understanding it, as having contributed to this problem. They feel that the Aristotelian effect on the development of most languages resulted in words which, although creating some order by placing objects in categories, ends up by not really doing justice to the unique characteristics of most objects thus described. This is especially true of the human organism.

Indications of this tendency to judge the individual in terms of stereotyping rather than in terms of his unique qualities as an individual, are revealed in the "picture" that is "conjured up" by such terms as "Communist," "capitalist," "reactionary," "radical," "Yankee," "blonde," etc. This tendency is aptly summarized by Otto Klineberg[12] as he points out, "Few people realize how much the existence of stereotypes may colour our relations with other people, even to the extent of seeing them differently as a result.

"Psychologists have long known that our perceptions of the external world, and particularly of human beings, are determined not only by what is *out there,* but also by what is *in ourselves.* What we see is determined in part by what we expect to see. If we believe that Italians are noisy, we tend to notice those Italians who are noisy. If in the presence of some who do not fit the stereotype, we may not even realize that they, too, are Italians. If someone says to us 'Look, those people are Italians, and they are not noisy,' we can always dismiss them as exceptions.

"Since there is no limit to the cases that can be so dismissed, we may continue to cling to the pictures in our heads, despite facts to the contrary. This does not always happen. Stereotypes do sometimes change in the light of new experience . . . If we have had them for a long time, however, we surrender them reluctantly."

Prejudice. Much research has been done in the behavioral sciences, to investigate the nature of stereotyping, particularly in the area of group prejudices. For example, in the 19th century, Lombroso[13] was preaching the doctrine that criminals, through their life of crime, began to reveal a "stigmata of degeneration" revealed in their faces. Lombroso's miscalculations are still taken seriously by many unsophisticated observers. But research by such individuals as the famous criminologist, Sir Charles Goring,[14] has shown that when photographs of criminals are interspersed with the photographs of non-criminals, judges could not select the criminals from non-criminals.

Ethnic stereotyping. In the area of ethnic stereotyping some of the most provocative studies have been completed. To illustrate, Bogardus[15] asked 110 business men and school teachers to rate a number of ethnic groups in terms of how acceptable they would be to them in terms of a "social distance scale." The pattern of acceptance and rejection of ethnic groups on the basis of stereotypes was surprisingly consistent.

Keeping in mind that rank orders of "social distance" desired from these groups could be rated on scales from "near to far," the results of these judgments based on Bogardus' sample were as follows: (1) Canadians, (2) English, (3) Scotch, (4) Irish, (5) French, (6) Swedes, (7) Germans, (8) Spanish, (9) Italians, (10) Indians, (11) Poles, (12) Russians, (13) Armenians, (14) German Jews, (15) Greeks, (16) Russian Jews, (17) Mexicans, (18) Chinese, (19) Japanese, (20) Negroes, (21) Mulattoes, (22) Hindus, (23) Turks.

Thurstone,[16] later repeating this investigation in a

slightly different way, found that these stereotyped patterns of judgment prevailed in all sections of the United States. More recently, when Hartley and Hartley[17] repeated this type of investigation, they found two groups rated even below the Turks—the Wallonians and the Pyrineans. The remarkable thing about this finding is there are no such groups as Wallonians and Pyrineans. This shows that ethnic or racial groups which are not even known by individuals may, nevertheless, sometimes be stereotyped as being unacceptable.

Katz and Braly study. Daniel Katz and Kenneth Braly,[18] in a widely cited study, examined characteristics most frequently attributed to ten ethnic groups. Traits most frequently assigned were surprisingly consistent with "images" of these groups in mass communication media (newspapers, magazines, radio, television, and motion pictures).

For example, Germans were consistently described as scientific-minded, industrious, stolid, methodical; Italians as artistic, impulsive, passionate, quick-tempered; English as sportsmanlike, intelligent, conventional, tradition-loving, conservative, reserved. Jews were described as shrewd, mercenary, industrious, grasping, intelligent, ambitious; Americans as industrious, intelligent, materialistic, ambitious, progressive, pleasure-loving, alert, efficient; Negroes as superstitious, lazy, happy-go-lucky, ignorant, musical, ostentatious, very religious, stupid, physically dirty.

Irish were described as pugnacious, quick-tempered, witty, honest, very religious, industrious, extremely nationalistic, superstitious, quarrelsome; Chinese as superstitious, sly, conservative, tradition-loving, loyal to family ties, industrious, meditative, reserved; Japanese as intelligent, industrious, progressive, shrewd, sly, quiet, imitative; Turks as cruel, very religious, treacherous, sensual, ignorant, physically dirty, deceitful.

These investigations generally agree with our earlier quotation from Klineberg that contact with "negatively stereotyped" groups does not alter opinions of the group. Individuals who do not conform to stereotypes of groups are isolated as being the "exceptions which prove the rule."

Other studies of patterns of stereotyping reveal similar patterns of prejudgment with respect to men, women, various occupational groups, the physically handicapped, the aging person, and so on. All of us belong to many different kinds of groups—ethnic, religious, sexual, occupational, and educational. So we are all, in some instances, likely to be judged in terms of existing stereotypes of the groups to which we belong rather than as individuals.

Human relations problem. Stereotyping presents problems in a broad range of human relations. The most important of these barriers to effective understanding of others results in the kind of circularity alluded to earlier. For example, in trying to understand why a person does something, we simply dismiss his behavior because he belongs to a certain group. We don't try to understand him as an *individual*. If a given woman is tardy, rather than trying to understand this behavior in terms of her unique motivation, we might simply say, "She's tardy because she's a woman." If a physician keeps a patient waiting a long time for an appointment, we might say, "What can we expect? This is the way doctors act."

In a similar vein the late Arnold Gesell,[19] with his elaborate descriptions of children from infancy to adolescence, unwittingly provided the basis for "pseudo-explanations" of behavior of children. If a child of two resisted instructions from the mother, the mother might decide—"Oh well, this is because he is two years old—this is the way Dr. Gesell says two-year olds behave," rather than exploring the unique motivations that her child might have had at this moment.

In conclusion. Particular attention should be paid in the business and industrial setting to the inhibiting influence of prejudgment or stereotyping. The basic substance of human personality which reveals the truly unique character of the individual must be understood thoroughly before attempting to evaluate any one. Evaluations based on stereotypes simply cannot do justice to the individual!

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Key Words for Indexing

Employes — Personnel
Management — Supervision

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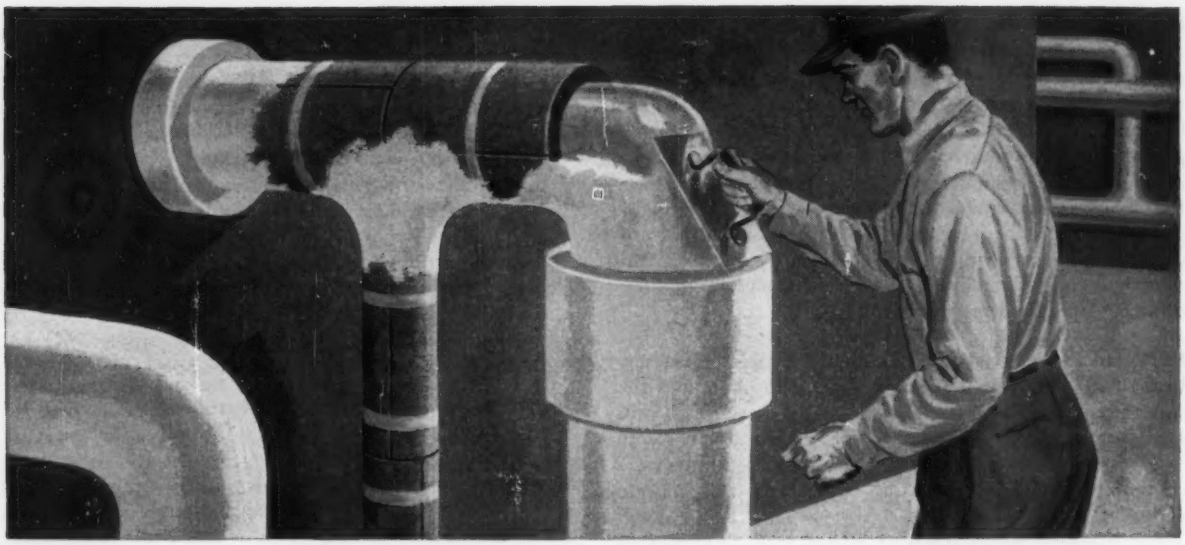

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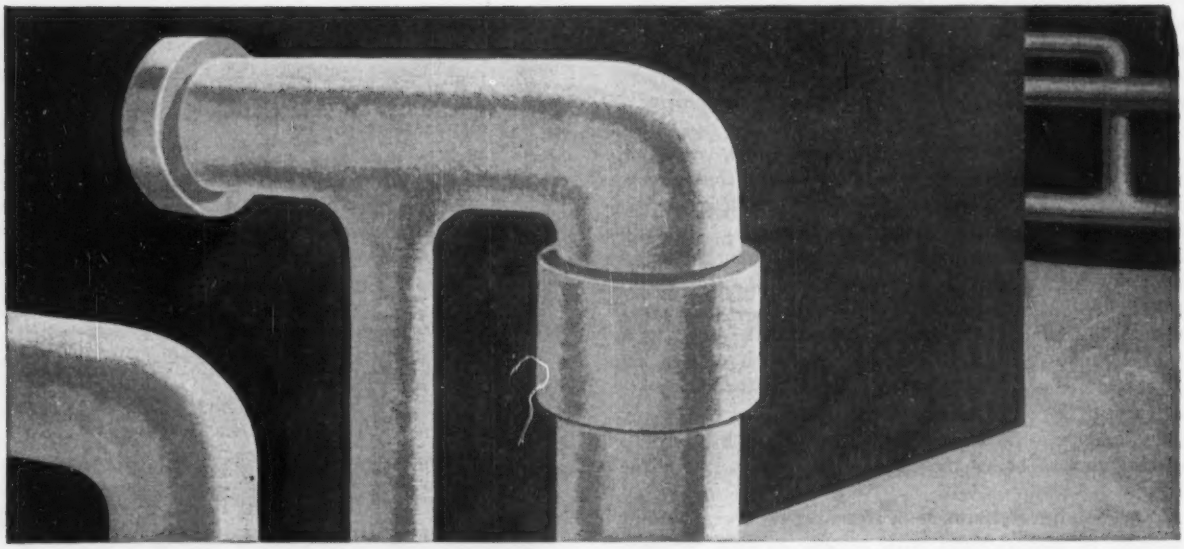

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16 Steps to a Sound Safety Program

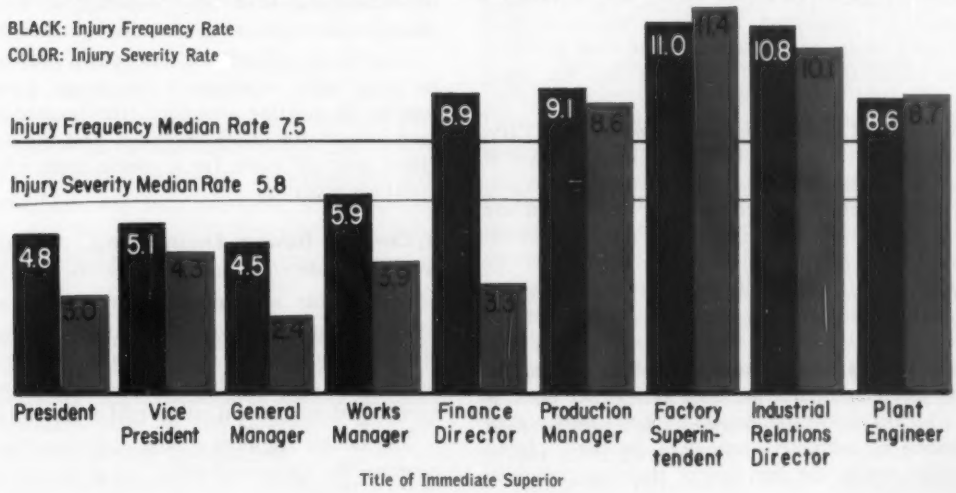
How long has it been since you sat back and really evaluated your company's safety program? This author did---and some of the safety problem areas he thought of may exist in your plant. Here's your chance to see if they do---and what you can do about it

Charles Homewood
Arabian American Oil Co.

The high cost of accidents demands their elimination. Accident prevention, just like any other job in the HPI, requires management action. When it receives adequate management attention, and is part of the processing function, accidents are reduced—efficiency improved. Following are 16 key problem areas in the safety picture that must be included in management's arrival at a safety "philosophy" before rapid progress can be made. How many does your company's safety program emphasize?

1. Careful Hiring and Placement
2. Training
3. Careful Design Engineering
4. Operations Analysis
5. Systematic Inspection of Equipment and Methods
6. Good Personal Protective Equipment
7. Encourage Employe Safety Suggestions
8. Accident Investigation
9. Accident Reporting and Statistical Analysis
10. First Aid and Medical Treatment
11. Accident Prevention Publicity
12. Safety Achievement Recognition

Organizational Position of Safety Engineers and Company Injury Rate



13. Motor-Vehicle Accident Prevention

14. Fire Prevention

15. Off-Job Safety

16. Accountability Reports

Effective accident prevention requires proper organization of the safety effort. Line officals must be responsible for accident prevention, just as they are for the efficiency of production. One way is for management to organize a top level safety committee to recommend policy and methods of running the program. This committee should include heads of all departments and the supervising safety engineer, and be under the chairmanship of the senior operating manager.

Staff safety engineers should assist the line in developing and carrying out accident prevention programs. In some companies, the staff safety organization is responsible for accident prevention. But this approach to the problem has not been as successful as when the plant manager takes responsibility for accident prevention then relies on his staff safety engineer for technical guidance.

In 1951, the American Society of Safety Engineers completed a survey on the effectivness of proper placement of the safety engineer. The chart on page 331 is taken from the survey. Note that injury frequency rates are lower in plants where the safety engineer reports directly to a member of top management. Rates are higher in companies where the safety engineer reports to lower levels of management. However, where strong management support is available, outstanding accident prevention records can be made no matter where the staff safety function is placed.

It is important to have the staff and line function completely understood. In small companies the function may be combined in one person. That person, when acting in his safety capacity, should remember he is acting as a staff man to other members of management.

The responsibilites and authorities of the staff safety division should be clearly defined. In some operations, the function of fire protection, accident prevention, and the handling of industrial injury claims and workmen's compensation are combined. In these companies there can be a much closer coordination of the total accident prevention effort than when the operations are separated.

Qualifications of persons in safety work may vary, but in the highly technical HPI, the most successful safety man is a competent engineer interested in people. The successful safety engineer must be devoted to the cause of accident prevention and be an enthusiastic salesman.

Now let's examine more closely our 16 key points of interest in a sound safety program.

1. Careful Hiring and Placement. When a man and his job do not match, the accident rate often rises. A company's hiring and placement effort is to insure a continuing source of competent employes, properly placed in jobs which make the best use of their special skills and knowledges. Physical aptitude or other psychological tests frequently are used to determine the person's psychological capabilities.

Unless the requirements of a job and the abilities of the man are properly matched, the chance he may have an accident is greatly increased. In initial hiring, the company should establish physical standards for new employes. After hiring, a re-assignment may become necessary for various reasons. Here, too, a comparison of job demands and employe skills is essential.

The comparison should be carried out by the employe's supervisor and a doctor, together with the placement specialist. Injury sometimes reduces the physical capabilities of the employe, or advancing age reduces his agility. Special comparisons of demands and abilities then should be made so the employe may be retained, but not exposed to hazards beyond his capabilities.

2. Training. Job training, including safety training, should start at the first contact a new employe has with the industry and continue until he retires. In the beginning, the new employe should get pre-job training which includes instruction in basic safety rules applying throughout the company.

Safety training is a continuing part of each supervisor's responsibility. Part of this is done in planning sessions before any new job is started. The supervisor should point out the hazards of the job and be sure all employes are aware of precautions that must be taken.

To keep the employes aware of safety hazards, safety meetings should be held, their frequency and length depending on the kind of work and degree of employe training. In the HPI, many operators hold a five-minute safety meeting before starting a tour and again call a special meeting when an unusual job is to be undertaken. Constrasting with the five-minute meeting, sessions lasting several hours may be held with design engineers before beginning a new project. Safety meetings should continue throughout the design phases of the project as considered necessary by the project manager.

In many situations, a training expert or a safety engineer can best conduct the training sessions. Before an employe becomes a supervisor, he should be trained in the fundamentals of safety supervision. This should include accident prevention methods in detail.

Conducting effective meetings is a skill which should be a part of a supervisor's equipment. Formal training sessions in holding meetings, the presentation of suggested items for safety meetings, and the availability of visual aids all make for a much more effective safety meetings program.

3. Careful Design Engineering. An employe must work in a safe environment if his efficiency is to be high and accidents minimized. Many plants are designed from the beginning with the thought of preventing accidents. Where safety is not a basic consideration in the building of a plant, there will be delays, and unneccessary expeditures required to make the work place safe.

The design engineer should call upon the staff safety engineer for his special skills, just as the designer calls on

the skills of the electrical engineer, the civil engineer, and others. The safety engineer can best make his contribution while the new plant is in the design stage. Later, his suggestions for change are more expensive, and more difficult to sell to the responsible line official.

4. Operations Analysis. A study of thousands of accidents shows they frequently result from poor or improper work methods. To study a job after an accident is essential to any organized safety effort. It is much more effective, however, if the operation is analyzed before it results in an accident. This can best be done through job safety analysis.

This job analysis provides information for training guides and clues to hazards that may be eliminated. It also assists in determining the tools and equipment that are necessary, and is essential for proper employe placement.

The analysis should not be on a crash basis. It should be a long-term program carried out by line supervisors with the help of safety engineers. Some companies are making one job safety analysis per month after a statistical analysis of their industrial injuries indicates which job should be reviewed first.

5. Systematic Inspections of Equipment and Methods. Safety inspections are a common denominator for all accident prevention programs. They should be a constant factor in programs of the individual supervisor, the division superintendent, the department manager, and the management fire and safety committee.

Inspections can be made by specialized men, such as mechanical equipment inspectors, electrical inspectors, building inspectors, etc. They also can and should be made by the staff safety engineer. It is well known that we become accustomed to unsafe conditions. These conditions or methods of work seen by an outsider immediately flash a warning. Consequently, if the condition or practice is corrected, an accident will be prevented.

One of the basic supervisory functions is to make safety inspections. Since most safety committees are organized to conduct inspections as one of their duties, its members should be properly trained. It is important to know what to look for, both in the areas of unsafe conditions and unsafe acts.

Following an inspection, corrective action must be taken. This is most effective when formally made a part of the fire, housekeeping, and safety inspection report. Obviously, the individual supervisor inspecting his own area on a daily basis will take corrective action without the necessity of a formal report. But the safety committee becomes ineffectual unless reporting is done on an organized basis.

6. Good Personal Protective Equipment. The ideal solution to a hazardous situation is to eliminate it. If that is impossible or impractical, steps should be taken to prevent employes from coming in contact with the hazard by suitable guarding at the source.

Whenever personal hazards are mentioned, we tend to think in terms of hard hats, goggles, gloves, safety shoes, aprons, fresh air respirators, etc. These are all essential to workers, but it requires leadership and persuasion to get the work force to wear protective equipment at all times. Hence, whenever possible, guarding at the source through engineering revision, should be the preferred solution.

The supervisor and safety engineer should consider each job to determine the most practical method of protecting personnel. It is not sufficient to say "put goggles on the worker." They must be suitable. They must fit; they must not cause irritation. And they must be acceptable to the employe. The wearing of personal protective equipment becomes more tiring when the work is carried out under high temperatures. It is most important in hot climates to insure adequate ventilation and careful fit of all personal protective devices.

The issuance of personal protective equipment can best be done at a centrally located point of issue when the number of employes is sufficient to warrant this. The attendant can be trained in the proper fitting of goggles, respirators, etc. He also can repair returned items, sterilize them and package them for re-issue, thus reducing the cost of personal protective equipment.

7. Encourage Employe Safety Suggestions. A company's work force is a mine of information. Employes frequently see ways to improve safety and the efficiency of their operations. A hazard may, unfortunately, be brought to their attention through an injury or a near miss. It may be that they bring experience from other jobs. A method of obtaining their suggestions is essential. Many safety suggestions are handled by the employe's immediate supervisor on an informal basis. However, some suggestions do not lend themselves to immediate action, since the supervisor may not have the equipment or authority to act.

There are many ways in which safety suggestions can be handled formally. In one of these, the reporter of the hazard completes the form and gives one copy to his supervisor, sends one to the Safety Division and retains a copy. The supervisor, as necessary, forwards the suggestion to the proper level of management for final decision. The employe is informed of the suggestion's outcome. Some companies make cash awards for the best "work improvement" suggestions. Many of the ideas have to do with accident prevention, and simulate the over-all safety program.

8. Accident Investigation. Accident investigation is essential to all accident prevention work. The fact that an accident has taken place, resulting in damage to property or injury to personnel, is factual evidence of the existing hazard. However, unless all the facts are determined without thought of fixing blame or determining negligence, an opportunity to prevent a recurrence will be lost. Often the causes of the accident are lost because those making the investigation are not skilled in proper procedures.

The person responsible for the employe who was in-

jured or the property that was damaged, should make the initial investigation and report. He should be assisted by the staff engineer and other specialists who may be able to add to the effective outcome of the investigation.

It is often helpful to have a management committee investigate accidents causing serious injuries or property damage. This committee may function best when headed by the department manager, and made up of the responsible superintendent, staff safety engineer, lawyer and secretary. The committee should be kept small. It should have the authority to call upon any employe either directly involved in the accident or having special skills which will result in a more thorough investigation and a more proper determination of causes for the accident. The recommendations of the committee should be reviewed by higher management and action taken to prevent recurrences.

Accident prevention information must be gathered on all accidents no matter how insignificant the damage or injuries may seem. Where the causes are readily apparent, the investigation should be short and the report brief.

9. Accident Reporting and Statistical Analysis. For accident investigation to be meaningful, the findings should be reported to a proper level of company management (and governmental agency, where this is required by law) so proper preventive measures will be taken. By using statistical methods, it is possible to find the areas of greatest accident potential and work toward maximum effectiveness.

10. First Aid and Medical Treatment. First aid and medical treatment of injuries is an important part of safety. In all work groups, certain employes and the supervisor should be skilled in emergency first aid. This results in life-saving action in times of emergency. Immediate treatment of all injuries, no matter how minor, is essential to prevent infection and complications.

In serious injuries, surgery and rehabilitation are essential. If the employe cannot return to the same type of employment due to the loss of a limb or loss of major body function, his rehabilitation to some other employment should start early during hospitalization. It is in these first crucial days after surgery that he can be best prepared mentally for the future. Without this preparation he may never again become a useful and productive member of society.

11. Accident Prevention Publicity. We all need constant reminders to work safely. In the field of accident prevention, these reminders take the form of posters, news bulletins, photographs, motion pictures, and in some instances, radio and television programs. Safety meetings are a normal means of reminding employes of the safe way to do a job and of the general hazards of their employment.

It is essential that safety publicity be on a professional level because it must compete with magazines, advertising posters and newspapers. If safety campaign publicity is of less interest than the competing media, it will be less effective in influencing the employe to adopt safe working habits.

12. Safety Achievement Recognition. In any safety effort, it is important to keep all employes informed of their record. Since the ultimate goal is to prevent accidents and fires, goals should be set so that improvement may be visualized. Many companies have contests between operating units. The unit which shows the greatest improvement is given special recognition. It is frequently difficult to compare these units fairly in view of their varying hazards. Therefore, contrast with their previous records is a more equitable method of measuring progress. Some contests give recognition to an organization which reduces its disability injury frequency rate by a certain percentage. Other programs give recognition when a specific number of man-hours have been worked. Other methods take into account both the frequency and severity of injury.

Awards traditionally have taken the form of certificates and plaques to be displayed by the winning unit. The plaque or certificate usually is presented at a group safety meeting, where local dignitaries as well as plant management take part. Such an award is useful. But when each *employe* receives a personal award, he shows a much greater interest in accident and fire prevention. Make use of ball point pens, mechanical pencils, key chains, cigarette lighters, pocket knives and similar types of personal awards when a plant or unit has made an outstanding safety record.

13. Motor-Vehicle Accident Prevention. In the HPI, motor vehicle accident prevention is an important part of the safety program. Large numbers of trucks and cars are used to move products, supplies and people from and to the work place. The general traffic situation affects all company employes whether driving on or off duty. An effective motor-vehicle accident prevention program depends on a properly maintained vehicle, an adequately trained and supervised driver, and competently enforced traffic laws.

Maintenance of vehicles is all important. A driver can't be expected to operate a vehicle with tires having no treads, poor brakes, bad headlights, an improperly adjusted steering gear, or without mirrors.

Drivers must be trained to handle the vehicle skillfully in varied conditions, and know the traffic signs and laws. It is important for each driver to be physically fit. But it is more important for him to know his limitations in visual perception, depth perception, glare recovery time, and reaction time. Tests designed to indicate these qualities are readily available. When the results are properly understood by the driver, he can compensate for his own personal reactions.

A driver involved in an accident must make a complete report so that the cause may be determined. He then should be counselled on methods of preventing a recurrence. The driver must understand the concept of defensive driving. The trained defensive driver can foresee and avoid collision with improperly driven vehicles in many instances.

Recognition of good driving records is essential. This recognition may take the form of a small pin or badge indicating the employe's number of safe driving years. (5) Petroleum Refiner No. 205E 10 on 11 baskx20 4-28

14. Fire Prevention. The flammable properties of most HPI products make fire prevention a fundamental of the safety program. Fires and explosions cause the greatest amount of damage. Petroleum fires are possible whenever a petroleum vapor, properly mixed with oxygen from the air to form a combustible mixture, is in contact with a source of ignition, such as an open flame or electric arc. Fires may be prevented by separating the petroleum vapor from the oxygen. Or, if the process requires combining these two materials, the ignition source must be eliminated.

Prevention of fires is possible by properly maintaining equipment in which the product is handled, processed, or stored so it will not escape uncontrolled to the air or ground. Sources of ignition must be closely controlled at all times through a fire or hot-work permit system.

Fire prevention begins with proper engineering design of the plant. The first line of defense against the spread of a petroleum fire is a well trained plant operator. He can cut off the supply of petroleum fuel and apply water fog or dry chemical to control and extinguish the fire. Damage can be held to a minimum if such prompt action can be taken.

15. Off-Job Safety. Another concern of industry is help employes and their families to reduce accidents in public areas and in the home. Most companies who keep records will find that five to ten times as many injuries are suffered by their employes off the job than at work. This ratio may be much higher in a company that has had a good job safety program, but has paid little or no attention to the off-job problem.

Interest in the employe after working hours is a proper function of the employer. The employe injured off the job is just as restricted in his productivity and suffers as much as the man hurt on the job. Justification for off-job accident prevention is clear on both moral and economic grounds.

It is not as easy to promote off-job safety, since there is no control of the employe's environment or activities. However, where a company has made safety a way of life through constant reminders, through safety meetings concerned with off-job safety, and with personal incentive to improve off-job safety performance, dramatic results have been achieved.

16. Accountability Reports. As in all area of management, accountability for accident prevention performance is essential in the over-all program. The frequency rate of disabling indsutrial injuries is not sufficent in itself to determine whether accident prevention progress is being made. A monthly report to management will indicate the accident prevention effort. This report should list:

- The number of safety inspections made
- Conditions corrected as a result of the inspections
- The number of safety suggestion from the employes made and acted upon
- The number of safety meetings and the subjects discussed
- The number of injuries treated by first aid attendants or medical personnel whether disabling or non-disabling, and whether on or off the job
- The number of motor vehicle accidents
- The number of fires
- The number of accidents causing property damage without injury.

Some companies set accident prevention goals, then measure their progress.

RESULTS OF ACCIDENT PREVENTION

The safety movement is now well established, and its records in the United States go back 50 years. In the United States deaths from job-connected accidents have been reduced by 50 percent, as compared with the 1900-1910 period.

Industrial injury frequency rates, first nationally collected in 1926 and measured as disabling industrial injuries per million man-hours worked, were reduced from 32 to 6.5 in 1959—an improvement of 90 percent. This is an improvement in all industry, and therefore, is an average. Through never ending effort, many companies have set astounding records of injury-free man-hours. In the chemical industry, 28,743,768 man-hours without a single lost time injury has set a world record.

In the petroleum industry, too, companies have set outstanding records. Safety progress can be maintained only through continuous effort. For instance, one company has a record of 14,300,000 man-hours in one operating unit without a single disabling industrial injury. But in another area one of their major refinery units was badly damaged by fire and explosion.

In the area of motor vehicle accidents, too, real improvement has been shown. The petroleum industry has reduced its frequency of accidents per million kilometers operated from 12.8 in the year 1945 to 9.8 miles in 1959.

If your company is weak in any of the 16 safety problem areas discussed above now is the time to do something about it—not when a death, injury, or heavy property damage occurs. ##

About the Author

Charles Homewood joined Arabian American Oil Co. in 1938 after graduation from the University of California at Berkely with a B.S. degree in electrical engineering. He has worked in Saudi Arabia since that time. Following experience in the engineering and operations departments he transferred to accident prevention work in 1944, and was made chief safety engineer in 1949, the position he now holds. Assignments have provided experience in accident prevention, fire protection and industrial injury compensation case handling. Mr. Homewood is a member of the Society of Petroleum Engineers and AIME.

Homewood

from GLASCOTE

service "on-the-double"

Meet Glascote sales engineer, Joe Delaney. Like all Glascote sales engineers, he puts great emphasis on customer service. Joe knows his product, how it best fits into the process and he knows the importance of customer satisfaction — after the equipment is installed.

Meet Glascote service specialist, Jack Kilroy. Jack spends most of his time helping Glascote customers prevent trouble through good maintenance procedures. But, if trouble strikes, he's on the job—and FAST.

"skin treatment"

kept cosmetics production on schedule

"Repair the reactor—no time to spare!" Glascote got this urgent call from a customer on a busy Monday morning.

The most essential piece of equipment in the chemical development laboratory of one of America's leading cosmetic manufacturers had been damaged during the weekend shutdown. An entire cosmetic production schedule hung in the balance.

Sales engineer Joe Delaney immediately called in a technical expert from Glascote's Cleveland plant. That was Jack Kilroy. Together, the two Glascote specialists rushed to the customer. Kilroy rolled up his sleeves before he got through the door.

In a matter of days, three custom-made patches were fashioned from tantalum. Kilroy worked into the early hours of morning to install the patches.

But there was trouble. One of the patches had to be remade. This meant shipping the sleeve to Cleveland. However, the Glascote plant came through with flying colors — it completed the job over a holiday weekend.

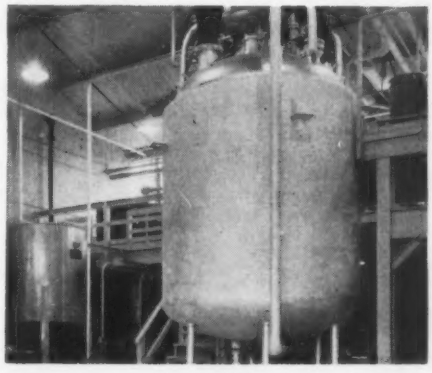
Kilroy installed the new patch. The 2,000-gallon reactor was now ready for full service. Glascote had done it — and in the shortest possible time!

Glascote's fast, professional service won the company's high praise. "It really saved the day for us," the plant manager exclaimed.

Three Glascote reactors are employed at the plant — two 2,000-gallon units and a 750-gallon unit. Recently, one of the 2,000-gallon reactors was reglassed with 778, the revolutionary Glascote formula extending acid resistance to 75° F higher operating temperature.

If you want efficient, economical glass-lined processing equipment . . . and dependable "on-the-double" service that backs it up, insist on Glascote.

Be sure to see the full Glascote process equipment line in the Chemical Engineering Catalog, pages 499-506.



LOOK FOR THE "BLUE COATS" AT THE BIG CHEMICAL SHOW, NOV. 27-DEC. 1... THEY ARE YOUR GLASCOTE REPRESENTATIVES. SEE THEM AT GLASCOTE BOOTH 596 NEW YORK COLISEUM.

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World's largest manufacturer of glass-protected steel products

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How to Do It...

Fast way to get . . .

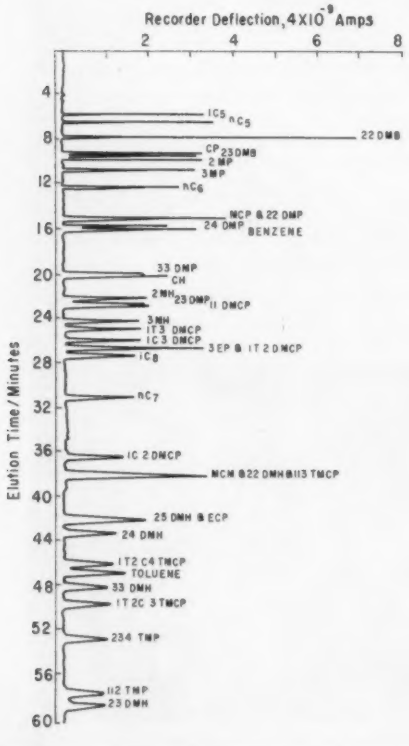
Better Chromatographic Separations

Coated capillary resolves 42 of 44 light gasoline fractions in one hour. Hexadecene is the substrate that turns the trick

Dan L. Ahlberg, Signal Oil & Gas Co., Houston
John Q. Walker, Barber-Colman Co., Houston

Many investigators have reported GLC methods for determining the 2 to 7 carbon saturated hydrocarbons plus benzene and toluene. Most of these methods involve multiple column runs with time of analysis from 4 to 12 man-hours per sample. Here's a report on the use of a coated, small bore column (capillary) which resolves 42 of the 44 normally occurring compounds in this region in one hour.

The column is 200 feet by 0.01 inch ID stainless, coated with n-hexadecene. The columns are easily prepared, operate up to 60° C without bleeding (although normally operated at room temperature), and even if overheated, can be easily cleaned and recoated. Since this is a small-bore column, the use of a highly sensitive detector such as a



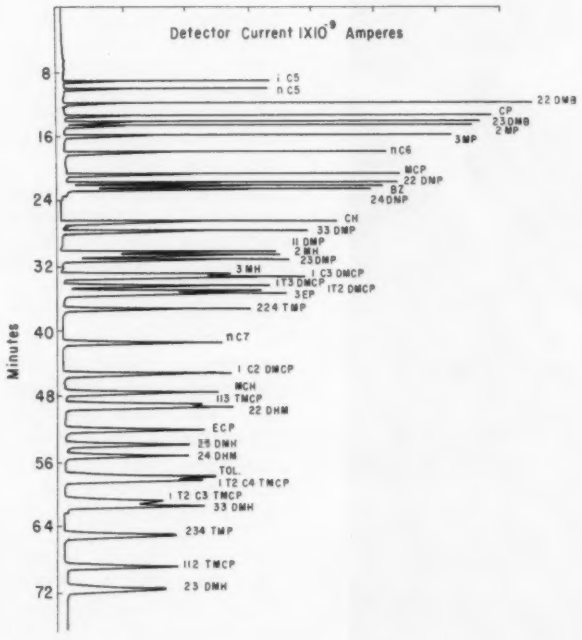


Figure 1:
MODEL: 61-C
SAMPLE: Gasoline 30-114°C
DETECTOR: Hydrogen-Flame
SENS: 10^{-11} ATTEN. 3
SUBSTRATE: Squalane
COL: LENGTH: 200′
TEMP. °C: F. H.: 275
D.T.: 150
FLOW ml/min:B: 150
CHART IPM: 1
ML INJECTED: 0.001
VOLTAGE: 300
REC. RANGE: —.25 to 5mv
CARRIER GAS: Argon
ID: 0.01″ TYPE 316
S.T.: 200 COL.: 26
DETR: 30
COL: 1

Figure 2:
MODEL: 61-C
SAMPLE: Gasoline 30-114° C
DETECTOR: Hydrogen-Flame
SENS: 10^{-11} ATTEN. 3
SUBSTRATE: Hexadecane
COL: LENGTH: 200′
TEMP. °C: F.H.: 275
D.T.: 150
CHART IPM: ⅛
ML INJECTED: 0.001
VOLTAGE: 300
REC. RANGE: —.25 to 5mv
CARRIER GAS: Argon
ID: 0.01″ TYPE: 316
S.T.: 200 COL: 26
DETR: 30

CORROSION DATA

20 Selected Results from Service and Laboratory Tests Comparing Ni-Resist with Cast Iron under 400 Different Conditions. Data on comparative service of Ni-Resist in the other corrosive environments may be obtained in the booklet offered below.

Corrosive Medium	Location of Test Specimens	Duration of Test	Temperature °F	Aeration	Velocity	Average Corr. Rates i.p.y. Cast Iron	Ni-Resist**	Type Ni-Resist Preferred
Acetone, 5 parts, and one part Oleic Acid—Linoleic Acid mixture	Separator Tank	131 days	35.6-102 dys. 68.0-150 hrs.	None	None	0.0004	0.00006	1-2
Ammonia, 5-6% by vol.; 150 p.p.m.; Phenol carried by water vapor	Top of phenol tower	309 days	215.6	None	750,000 cu. ft./hr.	0.002	0.0009	1-2
Ammonium, Saturated Sulfate in 3-10% H_2SO_4, plus coke oven gas	Saturator on "Cracker Pipe"	77 days	131	None	Violent	0.08	0.002	1
Calcium Hydroxide (Lime Water)	Laboratory		60	Some	None	0.003	0.0002	1-2
Carbon Dioxide, saturated aqueous solution	Laboratory		60	Some		0.03	0.001	1-2
Coal Tar (High Chloride Content)	Fractionating Column							
	Top	154 days	390	None	Some	>0.2	0.006	3
	Middle	154 days	515	None	Some	0.013	0.001	3
	Bottom	154 days	550	None	Some	0.006	0.003	3
Fertilizer, Commercial "5-10-5" Chemical Fertilizer	In contact with damp granules in storage	290 days	ATM	Some	None	0.010	0.003	1-2
Gasoline (end point containing H_2S & mercaptans plus H_2O. 11-13% chrome steel trays badly corroded)	On top of 24th tray of tower	70 days	370-432	None	Some		0.0027	
Hydrochloric Acid 2%	Laboratory		68			0.88	0.005	1
Paper pulp with small amounts of SO_2, Cl_2, H_2SO_4, pH 4-4.5	Decker effluent	198 days				0.006	0.002	1-2
Petroleum: Crude Oil (reduced, containing 0.584% S)	Bottom of crude tower	290 days	500	None	Turbulent		0.0033	1
Petroleum: Crude Oil (sour, cracked, 0.106% H_2S, & 0.066% mercaptan S)	Top tray or reflux tray of tower	132 days	342-352	None	Gas 26g/m		0.0028	1-2
Sodium Chloride	Salt Brine tank	180 days	50	Considerable	Some	0.010	0.003	1
Sodium Hydroxide 30% plus heavy concentration of suspended salt	Salt tank	82 days	180	Moderate	Moderate	0.0063	0.0001	4
Sodium Phenolate, with 20% (by vol.) tar acids. Total alkalinity of 20% by wt. NaOH	In phenol tower	329 days	248	None		0.002	0.0007	2
Steam condensate with dissolved O and CO_2	In condensate return line	30 days	180	Good	By flow	0.002	0.0004	1-2
Steam	In a nipple expanded pipeline from high pressure steam line	31 days	350	Good	120 lb.	0.002	0.0007	2
Water, brackish, East River, N. Y. C.	Water box of Steam Power Plant	334 days	54	Yes	High	0.010	0.002	1
Water, salt, from oil wells	In salt water pit	217 days	60	Slight	By flow	0.02	0.001	1-2
Water, sea	Intake flume	740 days	ATM	Considerable	5 ft./sec.	0.050	0.002	2

**Consult with Inco for specific corrosion rates for the various types of Ni-Resist.

How Ni-Resist irons "rate" against 20 corrosives

Also possessing excellent mechanical properties, corrosion-resisting Ni-Resist can be specified for a broad range of applications for the toughest service conditions

If you're looking for more satisfactory service life from your fluid handling equipment, you may be surprised by the economies that Ni-Resist* irons have to offer.

That's because Ni-Resist irons — with their Nickel content and austenitic matrix —deliver a unique combination of engineering properties:

They resist corrosion and erosion — they stand up to thermal shock—they have great strength and toughness—they resist metal-to-metal wear.

The unique properties of Ni-Resist irons are cast easily into compressors and blowers, filter drums, kettles and pipe. Ni-Resist irons prolong the life of pump casings, liners, wear rings and impellers. Boost the performance of valves and valve trim components.

In all these applications, Ni-Resist irons deliver the much needed corrosion resistance and mechanical properties. What's more, they *deliver them with cast-metal-economy.*

If the specific media in which you are interested are not given in this list of 20, you can obtain more complete corrosion data by writing us for a copy of "Engineering Properties and Applications of Ni-Resist." A postcard will do it. *Inco Trademark

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

Mechanical and Physical Properties of Ni-Resist

	TYPE 1	TYPE 2
Tensile Strength (thousand psi)	25-30	25-30
Thermal Expansion (70-400°F)		
(millionths per °F)	10.7	10.4
(millionths per °C)	19.3	18.7
Magnetic Response	Non-Magnetic	Non-Magnetic
Modulus of Elasticity (million psi) (at 25% of Tensile Strength)	12-14	15-16.2
Hardness, Brinell:		
low chromium	130-170	125-170
high chromium	140-190	140-190
Toughness (Izod Impact Test) (foot-pounds) 1.2 arbitration bar unnotched—struck 3" above supports.	100	100
Machinability	Good	Good

NI-RESIST

NICKEL MAKES IRONS PERFORM BETTER LONGER

For more data on advertised products, use cards, last page.

JOHN E. POLIS
Senior Design Application Engineer of our Molecu-Dryer Division, reports on

LOW COST
INSTRUMENT AIR DRYING

DELIVERY OF CLEAN, DRY AIR AT LOW COST for a "dry box" installation at one of our customer's plants . . . is now being accomplished with a Hayes MS Series Recirculating Molecu-Dryer. The same can be done for your instrument air system . . . where moisture causes rust, clogs up instrument ports, and creates freeze-ups in the air lines.

A NEW HAYES TYPE MSX MOLECU-DRYER has been developed to supply pure, dry air at −100°F and solve instrument air problems. An externally heated dryer, the MSX is a complete, compact, high-capacity unit featuring a simplified control system . . . makes drying and reactivating operations easy, automatic—at lowest cost ever.

SHELL AND TUBE DESIGN has been designed for safe, high pressure working ranges to 500 psig. Many other design innovations for which patents have been granted have also been applied to this and other Hayes Molecu-Dryer units. The unique feature of the new MSX, however, is the downflow stream which eliminates fluidizing of the desiccant bed, especially with high velocity flows.

SHORT CYCLES — CONTINUOUS FLOW. Dry and purge circuits of the MSX are independent and completely automatic . . . operate in alternating 4-hour cycles. Larger size Linde® Molecular Sieves are used, together with down-flow adsorption, to increase flow rates as much as 3 to 4 times that of comparable dryers with upflow stream.

A WIDE SELECTION OF FLOW CAPACITIES and pressure ranges are available to meet your particular instrument air drying needs. Bulletin 1060C gives full details on the new Hayes Type MSX Molecu-Dryer. For your copy, write C. I. Hayes, Inc., 853 Wellington Ave., Cranston 10, Rhode Island.

C. I. HAYES, INC.
Established 1905

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-Master (TM) power controls.

How to Do It . . .

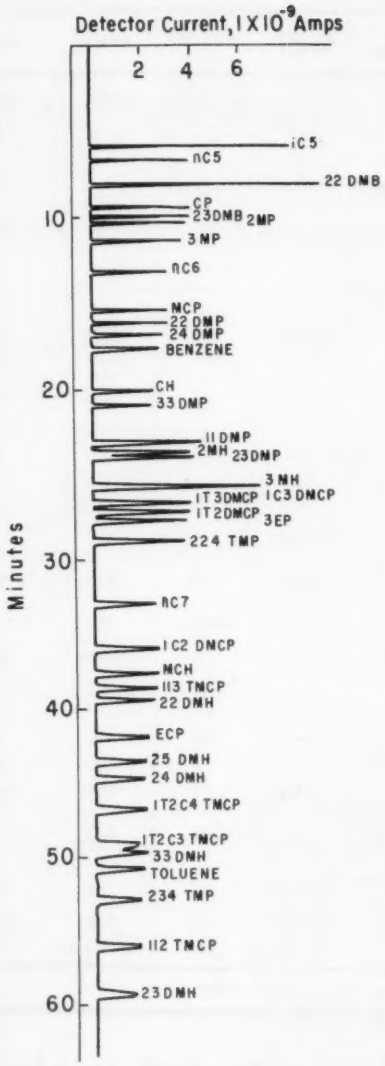


Figure 3:
Same column using n-hexadecene
SAMPLE: Gasoline 30-114° C
DETECTOR: Hydrogen-Flame
SENS: 10^{-10} ATTEN.: 2
SUBSTRATE: Hexadecene
COL: LENGTH: 200
TEMP. °C: F.H.: 290
D.T.: 150
FLOW ml/min: B: 400
CHART IPM: ⅓
ML INJECTED: 0.002
VOLTAGE: 300
REC. RANGE: 300
CARRIER GAS: Helium
ID.: 0.01" Type: 316
S. T.: 150 COL: 26
DETR: 30
COL: 1.5

flame ionization detector and sample splitter is a necessity.

A comparison of identical columns prepared with squalane (Figure 1), n-hexadecane (Figure 2), with the n-hexadecene (Figure 3) indicates that only one overlap (that of 3-methylhexane and 1 cis 3-dimethylcyclopentane) occurs. All other components, especially benzene and toluene, are either completely resolved, or at least quantitatively separated in this equal volume test mixture. Note that in the C_6 region separations are such that the column can be used for trace analysis on high purity products such as benzene, n-hexane, methylcyclopentane and cyclohexane.

The column is now being evaluated for use in olefin separations and dry gas streams.

Use Old Speedometer Cable To Bend Instrument Tubing

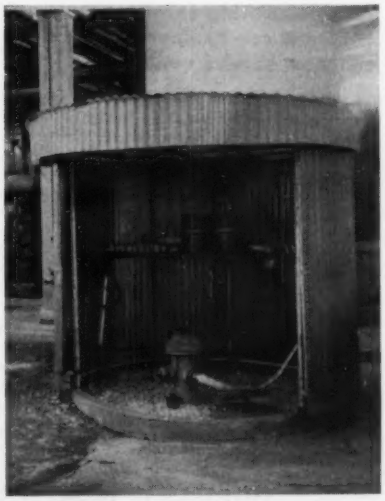
When it is necessary to replace a section of small piping used in instrumentation, and the new pipe or tubing has to be bent to shape, either fill it with salt first, or insert a piece of old automobile speedometer cable.

Either method keeps the tubing from kinking, and salt is better than sand since it washes or dissolves out completely.

Item by Harry Miller, Sarasota, Fla.

Fire Plug House Stores Fire Fighting Equipment

At the Westlake, La., refinery of



For more data on advertised products, use cards, last page.

we make stainless steel valves ...nothing else

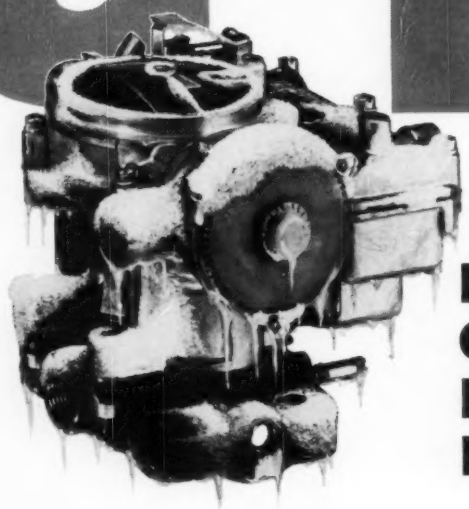
ALOYCO 111 Gate Valve for 150 lb. service features double disc ball-and-socket wedges. They are free to rotate and are non-fouling in any position which insures tight closure. There are Aloyco valves and alloys designed for every type of corrosive service.

SPECIALIZATION! Isn't it reasonable to believe that the one company with experience, facilities, research and service all devoted to a single product is your best source of supply? The modern Aloyco foundry, for example, is designed to produce one end product only: pressure-tight Stainless Steel Valve castings of the finest quality.

ALLOY STEEL PRODUCTS COMPANY
LINDEN, NEW JERSEY

Longer Lasting
ALOYCO
VALVES
1ST IN CORROSIVE SERVICE

S-41-K



FIGHTS CARBURETOR ICING ECONOMICALLY

Even under the most critical carburetor icing conditions, S-41-K at only 50 ppm stops stalling and rough idle economically.

At the same time—for no extra cost—S-41-K offers year-round protection against troublesome carburetor deposits.

WRITE TODAY for your copy of the S-41-K booklet reviewing extensive engine research, road testing and statistical data. Send your request to . . .

Central Soya
Chemurgy Division
1825 N. Laramie Ave., Chicago 39, Ill.

How to Do It . . .

Continental Oil Co., the fire plugs are placed inside glass fibre houses and the fire hoses connected up, so that in case of fire, all the operator has to do is grab the hose and turn on the water. Where foam chemicals are needed, the water nozzel knocks off and a foam nozzel is installed with the twist of the wrist. Five-gallon buckets of foam chemicals are placed on a shelf above the fire plug so that they are readily available to dip in the suction leg of the foam nozzel.

Liquid-Liquid Separator Needs Adjustable Overflow

Gravity type decanters of the type shown in Figure 1 are frequently used to separate immiscible liquids. In designing them, it is usually necessary to locate the overflow weirs and the liquid interface. The customary method for determining these is by equating the weight of the light liquid plus the weight of the heavy liquid in the decanter proper, to the

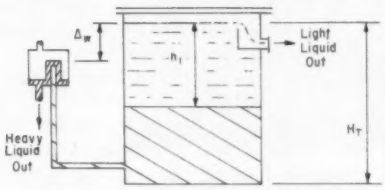
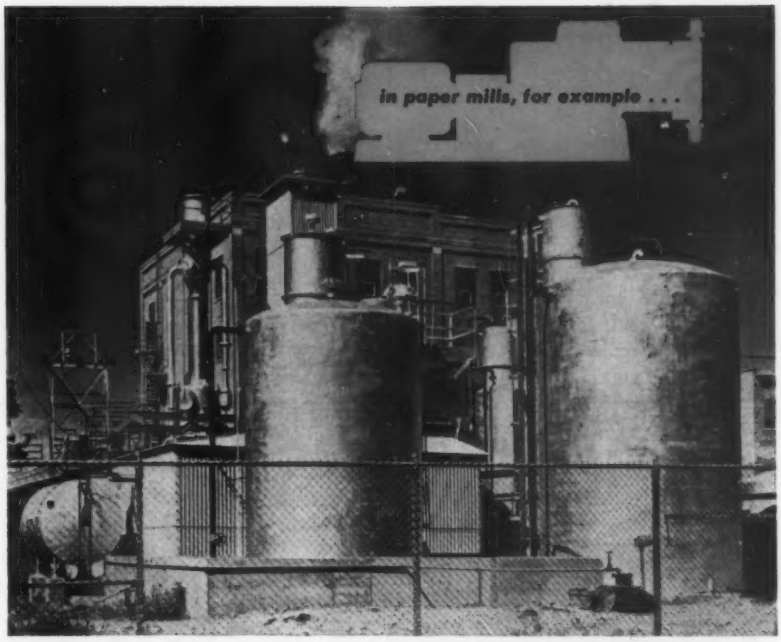


Figure 1—Gravity type liquid separator.

YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Hydrocarbon Processing & Petroleum Refiner*, P. O. Box 2608, Houston.



Pulsafeeder compounds chlorine dioxide bleach in perfect proportion without leakage

For Nekoosa-Edwards Paper Company, a special quintuplex Pulsafeeder provides continuous production of a bleaching compound that is too unstable to store. Each of the five heads is independently adjustable to meter out the proper proportion of water, sodium chlorate, sulphuric acid, and two additions of methanol. Result: a critically precise formulation of chlorine dioxide, with total output controlled by a single variable speed drive to keep pace with process rate. Never a drop of leakage . . . never a trace of corrosion . . . in over four years of steady use!

PULSAFEEDER IS THE METERING PUMP THAT:

withstands the hardest-to-handle materials you can feed into it . . .

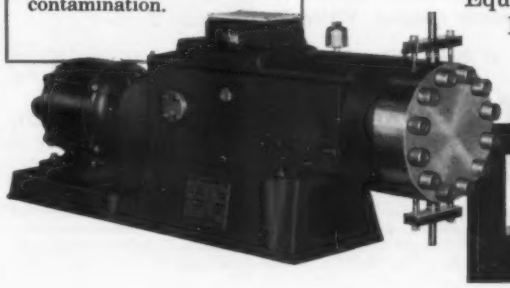
meters them at critically controlled flow rates . . .

never leaks a drop . . .

and completely seals pumping fluids from process materials so there can never be a trace of contamination.

The harder your materials are to handle, and the tighter your tolerances, the more you need a Pulsafeeder. Choose from today's most complete line—in flow rates from a few drops to 15.7 gallons per minute—with reagent heads resistant to any material you use.

WRITE for Catalog 59. Lapp Insulator Co., Inc. Process Equipment Division, 1523 Poplar Street, LeRoy, New York.



Lapp

For more data on advertised products, use cards, last page.

weight of the heavy liquid in the underflow pipe.

This procedure has a number of disadvantages. First, it does not explicity point out the important variables involved. In cases where the interface in an actual decanter is not properly located, the correction to the difficulty may not be readily apparent. Second, it is often necessary to make a calculation for varying conditions to make certain that the interface is always in the desired range. In this situation, the customary calculation method becomes cumbersome.

By algebraic manipulations it is possible to derive a very simple equation which clearly shows the relations between the important variables. This equation is:

$$h_1 = \frac{(\Delta_W)\ (S_2)}{(\Delta_S)}$$

h_1 = distance of the interface to the top liquid level in inches.

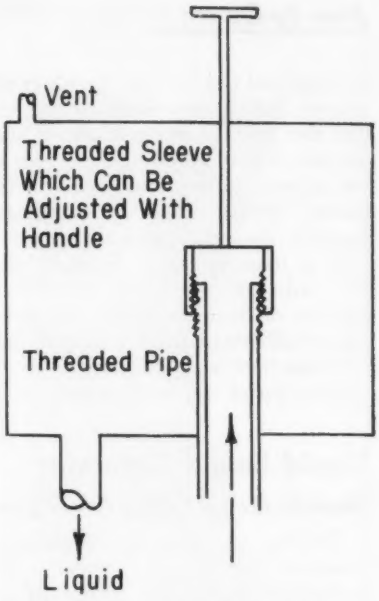


Figure 2—Weir adjusting device.

Δ_S = Specific gravity of heavier liquid minus specific gravity of lighter liquid.

Δ_W = Overflow level of light liquid minus overflow level of heavy liquid in inches.

S_2 = Specific gravity of heavy liquid.

From this equation, it can be seen that unless the overflow weirs are properly located, h_1 can be greater than H_T leading to a condition where both light and heavy liquids will pass through the underflow pipe. It can also be seen that when the specific gravity difference between the two liquids is small, a slight change in the specific gravity of either liquid can cause a large change in the location of the interface.

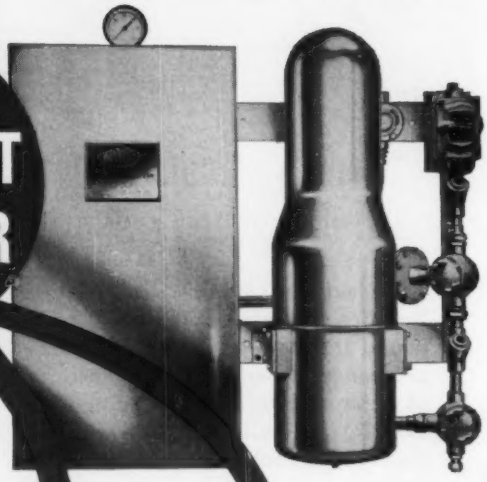
Example. If $\Delta_W = 2$ inches, the heavy liquid has a specific gravity of 1.000, and the light liquid has a specific gravity of 0.940, h_1 is 33.3 inches. If, due to a temperature change, the specific gravity of the heavy liquid became 1.010 and that of the light liquid became 0.960, h_1 then becomes 40.4 inches.

Because of this sensitiveness, it is recommended that when handling liquids of close specific gravities, a means be provided for adjusting the distance between the overflow of the light and heavy liquids. Such a device is shown schematically in Figure 1, and detailed in Figure 2.

Benjamin Smith, American Cyanamid Co., Bridgeville, Pa.

now on-stream

TOTCO END-POINT ANALYZER



optimum returns through quality control

Among companies now using one or more Analyzers for monitoring or controlling are:

The Atlantic Refining Company
Gulf Oil Corporation
Mobil Oil Company
Richfield Oil Corporation
Standard Oil Company of Calif.
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Applications include quality control of reformer feed, gasoline and distillate components, and "special" products.

Permits closer control to end-point specifications and increased yield. Continuous analysis improves quality. Write for Bulletin 6000-11.

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Consider a Butterfly Valve for your next control valve job. Compactness, ease of installation and low initial cost are definite plus features you can count on when using a butterfly valve.

Fisher-Continental eliminates the need for large massive power actuators with the introduction of the Series 480 P.O.P. pneumatically operated piston. You get the power, speed and compactness that's needed while still retaining the advantage of low initial and installation cost. Fisher-Continental Butterfly Valves with the 480 P.O.P. can handle high pressure drops of several hundreds of pounds depending on size of body and shaft.

It will pay you to find out how many ways Fisher-Continental Butterfly Valves can help you.

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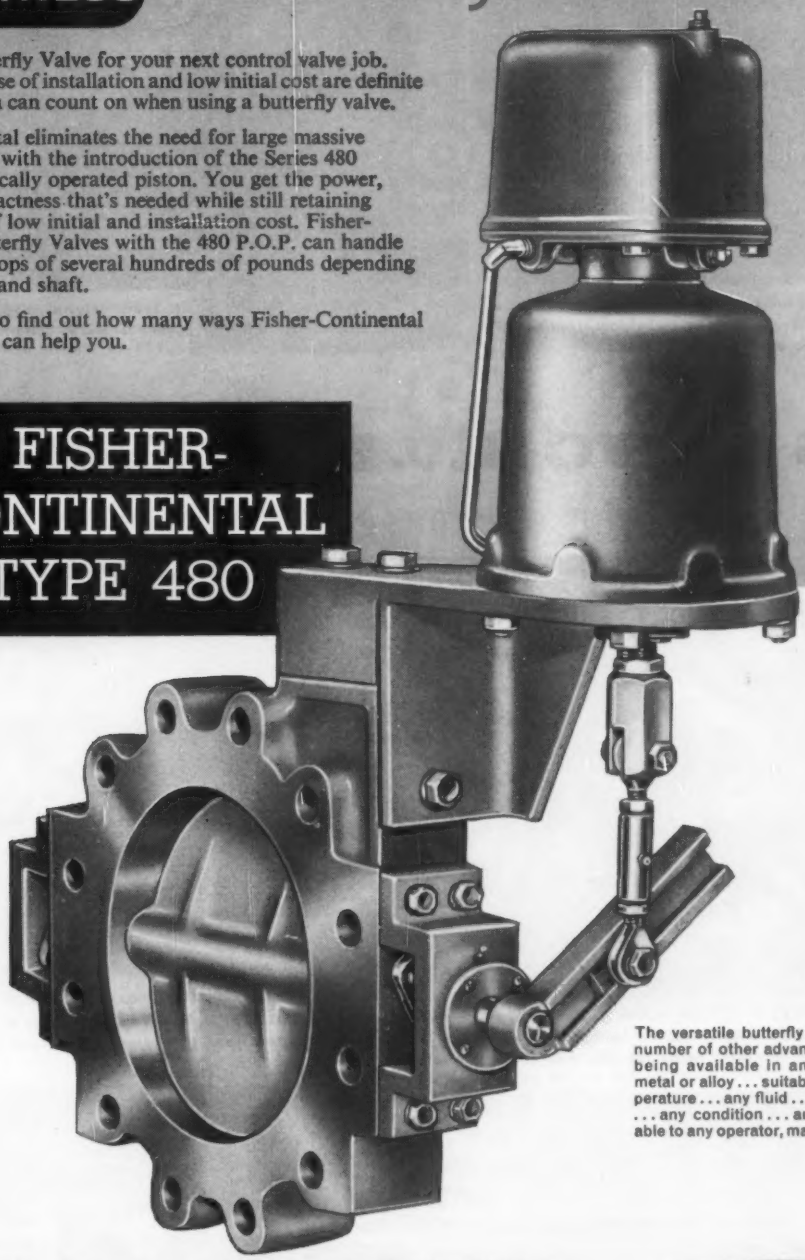
TYPE 480



The versatile butterfly valve offers a number of other advantages such as being available in any size... any metal or alloy... suitable for any temperature... any fluid... any pressure... any condition... and it is adaptable to any operator, manual or power.

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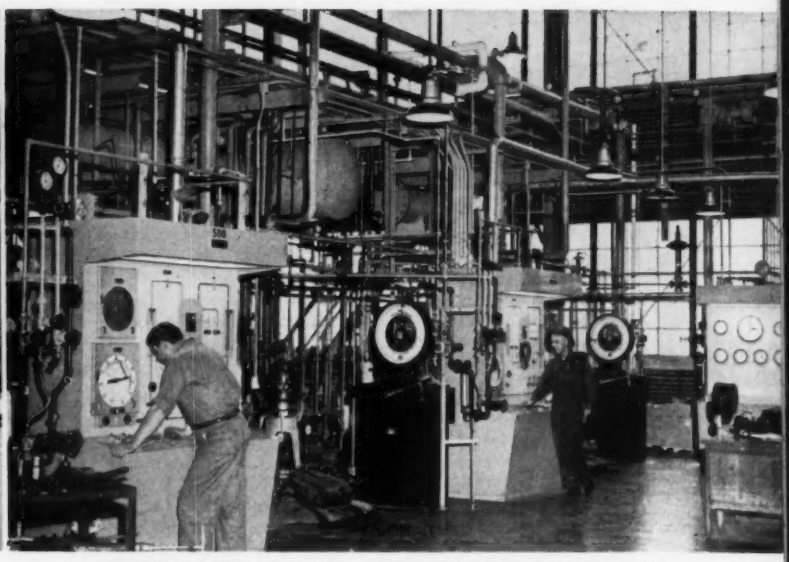
EMULSION SAMPLES are carefully tested in research laboratory at Brea, California. Tretolite technicians continuously seek new products to answer industry needs.



CONTROL CENTERS at St. Louis (illustrated), Brea, and Odessa, Texas, plants utilize latest equipment to insure uniformly high quality of Tretolite products.

RESEARCH...EXPERIENCE

PRODUCTION FACILITIES in St. Louis include research and development headquarters with pilot laboratories. Tretolite's founder, who originated the use of chemicals to break oil-and-water emulsions, was a St. Louis chemist.

CALIFORNIA PLANT at Brea is one of network of manufacturing operations providing widespread distribution of Tretolite products.

COMPANY-OWNED WAREHOUSE at Odessa—like those in St. Louis; Brea; Houston, Texas; Great Bend, Kansas; and Liverpool, England—facilitates prompt, economical deliveries.

ALWAYS AVAILABLE for on-site testing, computations, and recommendations is Tretolite field service engineer, shown here taking line sample at ACT station.

SERVICE ENGINEERS' assistance is offered wherever oil is produced or refined. Company planes are used to reach remote and off-shore locations.

IN-FIELD TESTING by the Man in the Red Car is familiar and valuable to oilmen in Canada, Latin America, and overseas, as well as in United States.

..SERVICE...result in

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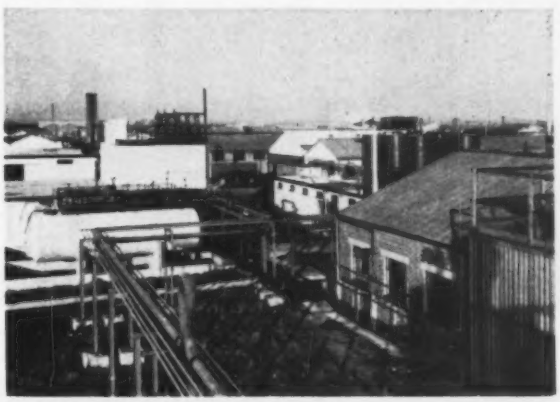
Among the "ingredients" in every drum of Tretolite products are the company's unparalleled research, experience, and service—directed toward the most effective possible treatment of petroleum at the lowest cost. Tretolite's extensive laboratory and field research, constantly seeking new and better formulas, has produced more than 600 oil-treating patents. Tretolite pioneered in this highly-specialized work almost 50 years ago, and today maintains a larger staff of field service engineers than any other supplier of petroleum demulsifiers, corrosion inhibitors, paraffin removers, and other additives and preventives. For help in saving dollars wherever you treat crude, ask the Man in the Red Car.



MODERN MANUFACTURING facilities and laboratories near Liverpool, England, and Petrolite Limited's engineering staff in London produce Tretolite chemicals for the Eastern Hemisphere.

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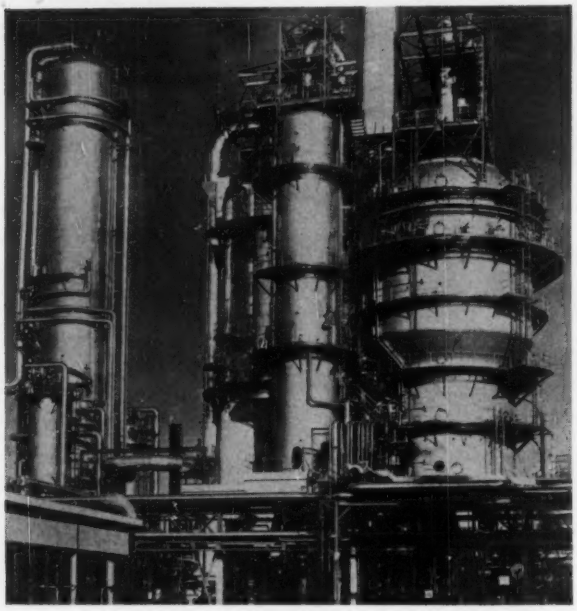
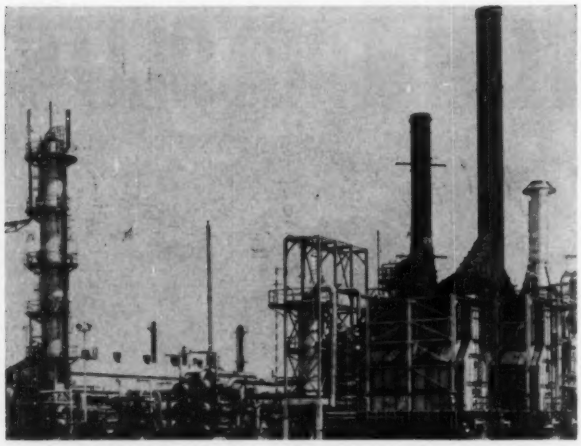
TP-61-2

Who's Building in HPI...



Royal Dutch Shell: Largest of three.



Platformer at Caltex refinery.

Dutchmen Leaders In European Refining

Holland, the home of the windmills, dikes and the Zuider Zee, is prepared for the challenge of tomorrow in meeting Europe's ever-expanding petroleum requirements. With a total annual processing capacity of 23 million tons, Dutch oil refineries are now supplying considerable quantities of petroleum products each year to countries all over Europe.

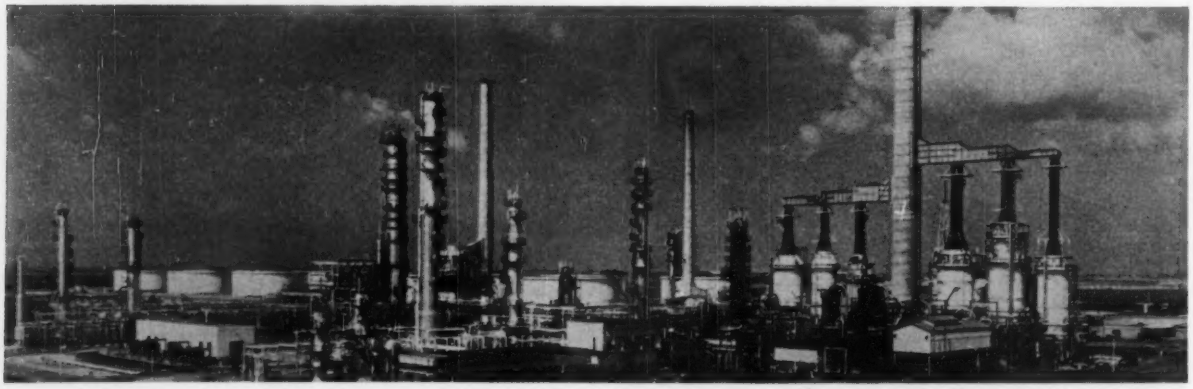
Although The Netherlands has many oilfields, the total national yield is sufficient to cover only 25 percent of the country's petroleum needs. Thus, the major proportion of oil has to be imported.

The Netherlands has three oil refineries: Shell Nederland Raffinaderij N.V. (Royal Dutch Shell Group), the refinery of Esso Nederland N.V., and that of Caltex (Nederland) N.V. Petroleum Maatschappij. All three are situated in the same area—Pernis and the Botlek vicinity near Rotterdam.

The Shell refinery is the largest of the three with a processing capacity of 15 million tons of crude oil per year. Over three-quarters of the production is exported.

Alongside the refinery installations, a petrochemical industry is being built up by a Shell subsidiary, Shell Nederland Chemische Fabrieken N.V. Separate plants exist for making detergents, polyvinyl chloride, various organic solvents, synthetic glycerine, and epoxy resins. The latest plant for production of synthetic rubber on a butadene-styrene basis was put into operation in 1960. New plants are now being built for making polypropylene, polyisoprene and polybutadiene rubber.

Adjacent to Shell's installation is the refinery of Caltex Petroleum Maatschappij (Nederland) N.V. It launched operations in 1950 and has an annual crude oil capacity of 3.25 million tons.



Esso refinery in the Botlek area near Rotterdam.

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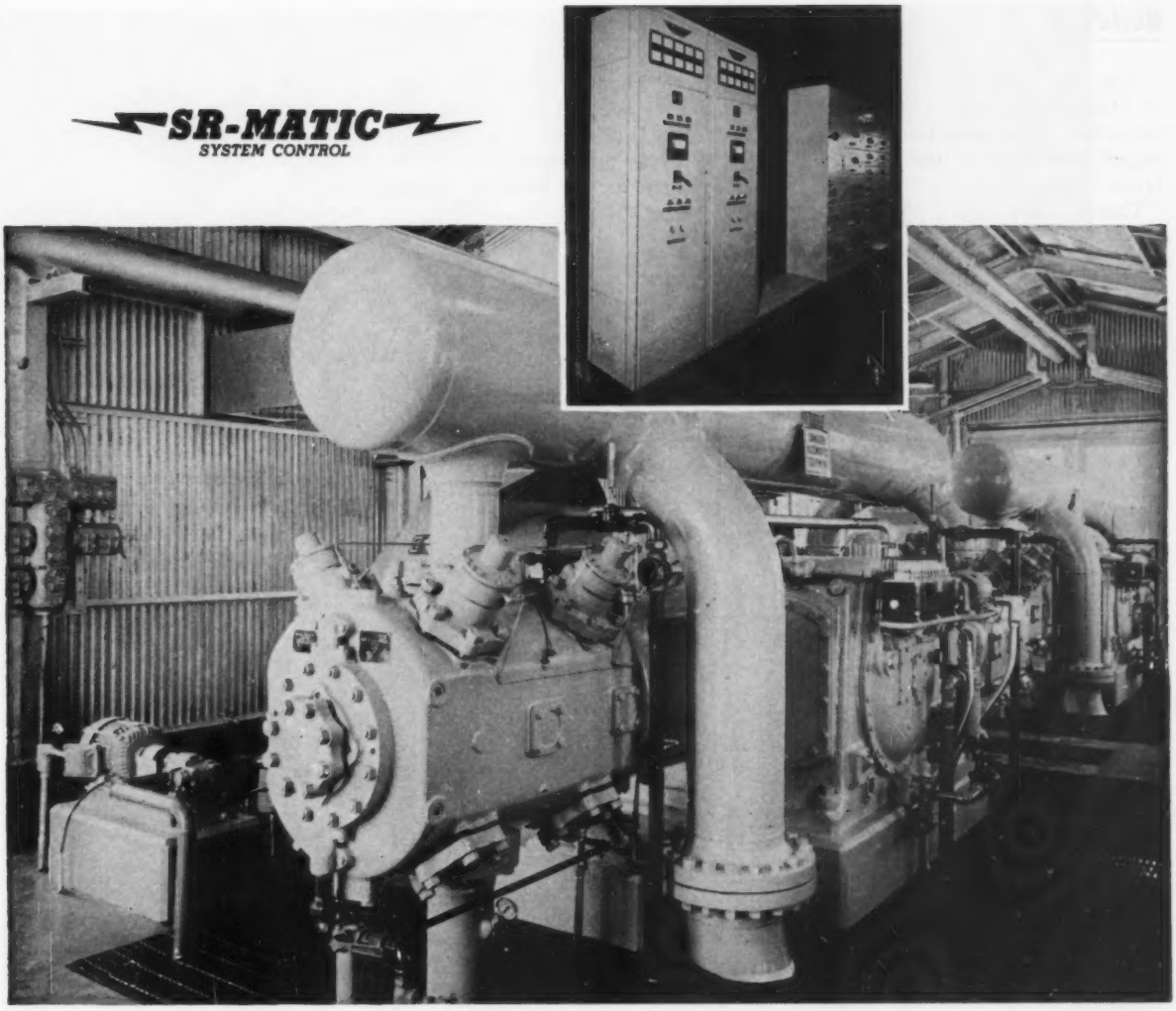
SYSTEM CONTROL



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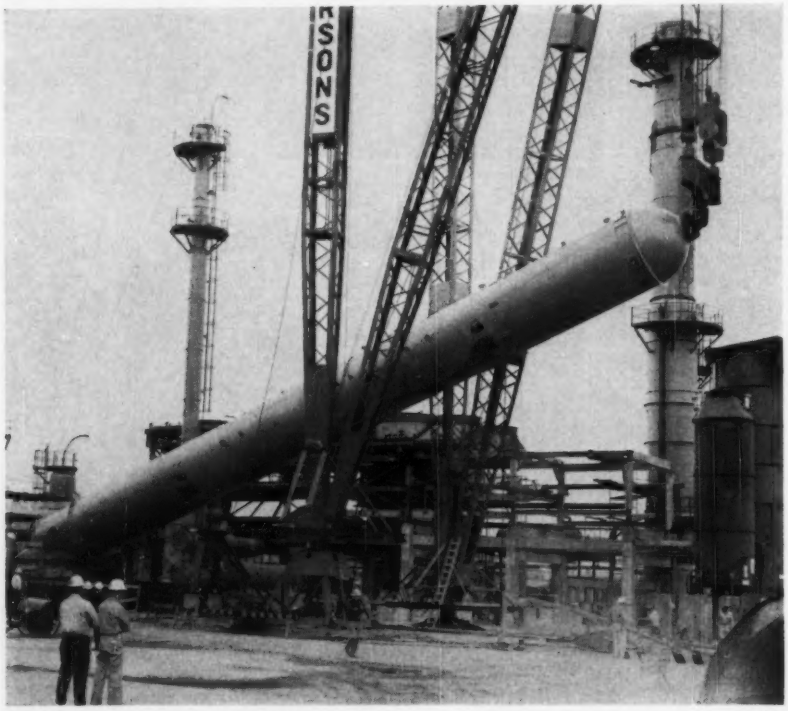
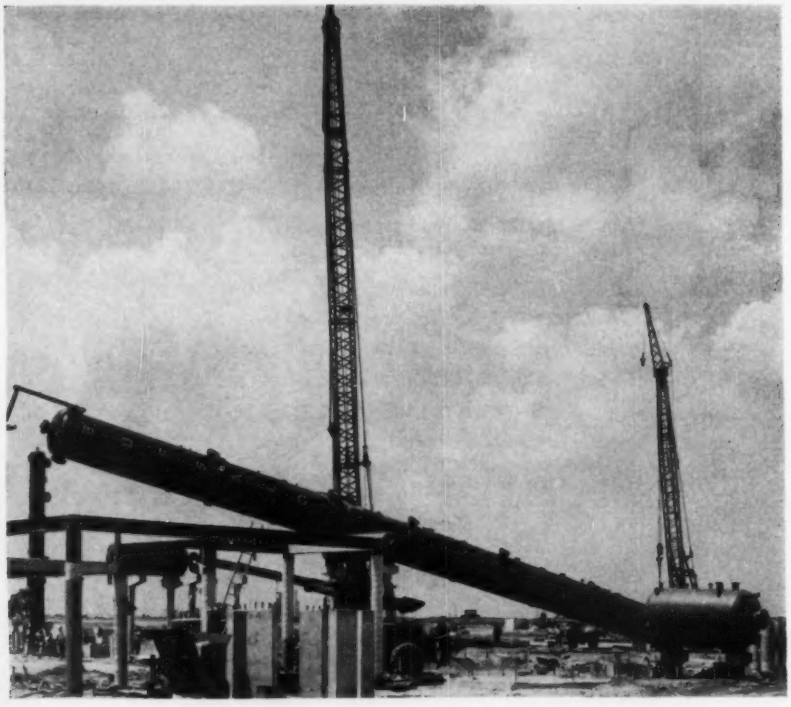
Building . . .

Esso Nederland N.V., a subsidiary of Standard Oil Co. (New Jersey), owns the third plant, which has a capacity of about 5 million tons of crude oil per year.

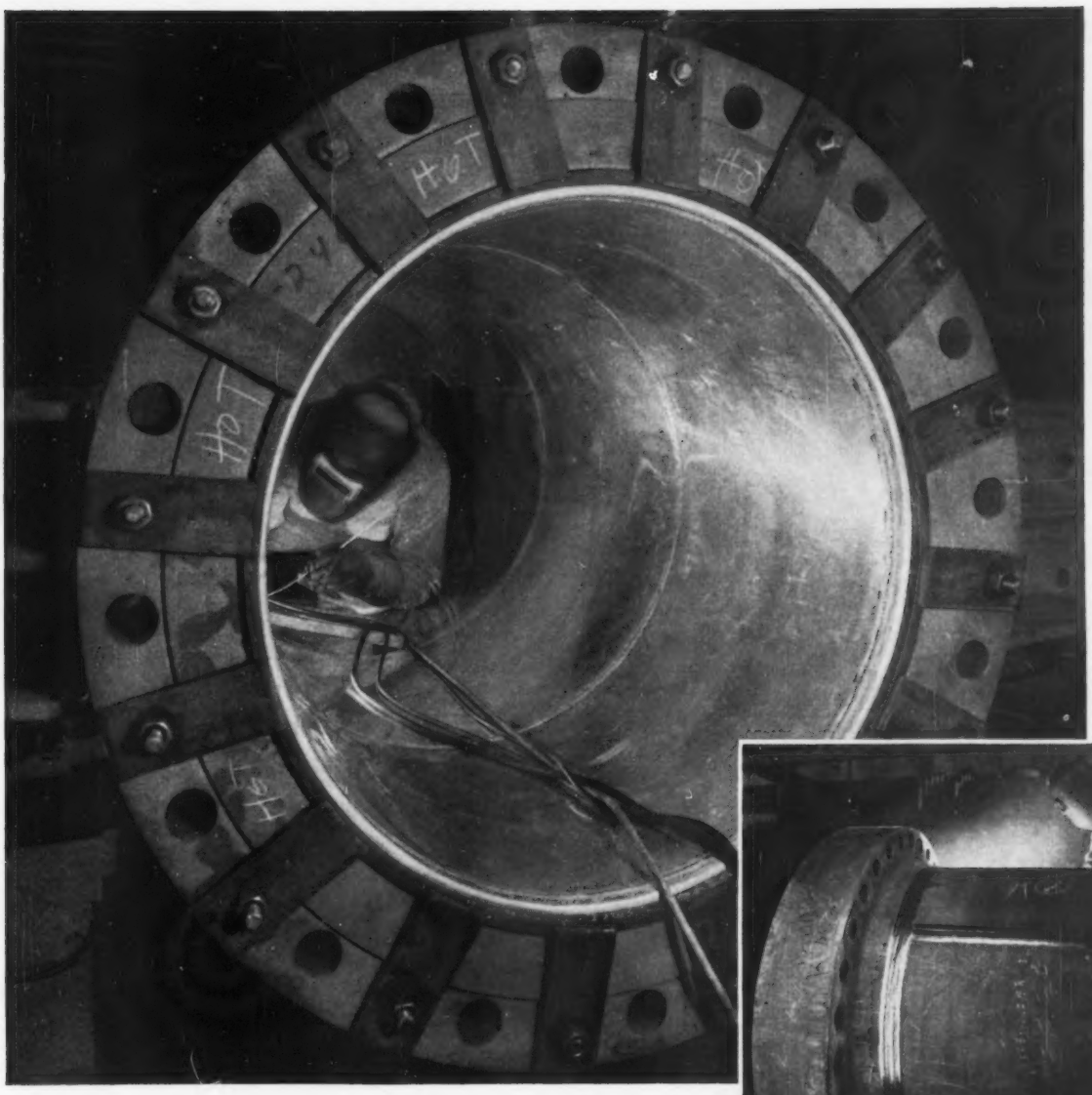
Construction began this year on a new Esso plant, which when completed in 1963, will be able to produce 220,000 tons per year of aromatic-base products for the chemical industry, such as benzene, toluene and paraxylene.



Weighing more than 400 tons, this huge steel reactor forms a key part of new multi-million-dollar Isocracking unit now being built by The Standard Oil Co. (Ohio) at its Toledo refinery. Unit will have 7,500-bpd capacity.



Naphthalene column, largest tower at new naphthalene plant under construction at Tidewater Oil Co.'s Delaware refinery, is raised into position. Tower is 126 feet high and weighs 45 tons.



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The Nooter welder pictured here is lining a reactor with a 1/16″ thick pure silver sleeve . . . an excellent example of Nooter's specialty of fabricating all types of pure metals, alloys and clad materials.

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For the latest Nooter publication, write for Bulletin 100, "Titanium Facts".

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Building . . .

Mobil Chemical Co. has awarded The Fluor Corp., Ltd., a contract for detailed engineering, purchasing and construction of benzene extraction facilities at Beaumont, Texas. Fluor will build a 2,300-bpd pyrolysis gasoline hydrogenation unit and a 12,500-bpd benzene recovery unit. Designed by Socony Mobil Oil Co., the Hydrotreater will consist of a reactor, a caustic wash unit and a stabilizer. The Hydrotreater will purify feed stock to the Udex unit, which is designed and licensed by Universal Oil Products Co. The Udex unit will consist of an extractor column, a solvent system and aromatic fractionating columns. Completion is set for February 1962.

Tidewater Oil Co. has received bids covering construction of a gas processing plant in Evangeline Parish, Louisiana. The plant will serve the Opelousas and other fields in the area and will initially process about 27 MMcfd of gas.

American Oil Co. is nearing completion of two new processing units in its modernization program at Texas City. The 150,000-bpd pipe still and 14,600-bpd alkylation unit are almost complete. A third big unit, a 47,600-bpd cat cracker, is well on the way to completion. The M. W. Kellogg Co. is constructing the pipe still and cat cracker; Fluor Corp. has the contract for the alkylation unit.

Tenneco Chemical Co. has awarded a contract to Crawford and Russell, Inc., for construction of a vinyl chloride monomor plant on the Houston Ship Channel. The plant, to have a 200-million-pound-per-year capacity, will be part of Tenneco's new petrochemical complex.

Shell Oil Co. has placed a 5,000-bpd hydrotreater on stream at its lube oil unit, Martinez, Calif., refinery. Contracted by C F Braun & Co., the unit removes sulfur and other impurities from lube stocks.

Sun Oil Co. plans to increase its propylene production by 150 percent at its Marcus Hook, Pa., refinery. The expanded facilities will have a design capacity of 180 million pounds of high-purity propylene per year and will raise Sun's overall production to 300 million pounds annually. Construction will cost $2.2 million.

Lyda Hunt-Herbert Trusts has started building a refrigeration-absorption type gas processing plant near McGregor, N.D., close to the Canadian border. The 12-MMcfd facility, being engineered and constructed by O. L. Olsen Co., will cost $2 million. Completion is scheduled for December 1961.

Standard Oil Co. of California is building one of the tallest petroleum refining towers in the world at its Richmond, Calif., refinery. The unit, a fractionating column, is as high as a 27-story building. It will separate orthoxylene from highly purified feed stocks for use in making phthalic anhydride. The fractionator will be linked to two lesser-sized towers which are part of the overall xylene extraction and separation system.

Cities Service Petroleum Co. has started design work on its naphthalene plant to be built at the East Chicago, Ind., refinery. A hydrodealkyla-

in cat cracker at SHELL*

Tough Plibrico Refractories record top-flight performance

Workman gunning Plicast Tuff-Mix on catalyst regenerator wall at Pernis.

Nearly all of Shell's fluid catalyst cracking plants throughout the world use Plibrico linings in the regenerator, cyclons and transfer lines that are supplied and installed by N. V. Plibrico, Rotterdam.

For more than 3½ years, (1,292 days to be exact), Plibrico refractories lining the cat regenerator at Shell's Pernis (Holland) refinery were subjected to continuous scouring action. Despite this, inspection at the end of the period revealed that only minor repairs were needed.

Such outstanding performance is typical of Plibrico products and reflects the scientific knowledge and engineering skills acquired in almost 50 years' service in every field employing refractories.

Plicast Verilite, a lightweight Plibrico castable excelling in insulating properties was used as the insulating component in the No. 2 regenerator. This was faced with a layer of durable, abrasion-resistant Plicast Tuff Mix, applied pneumatically onto stainless hexsteel mesh reinforcing.

WRITE FOR COMPLETE STORY and advantages of Plibrico linings for refinery vessels.

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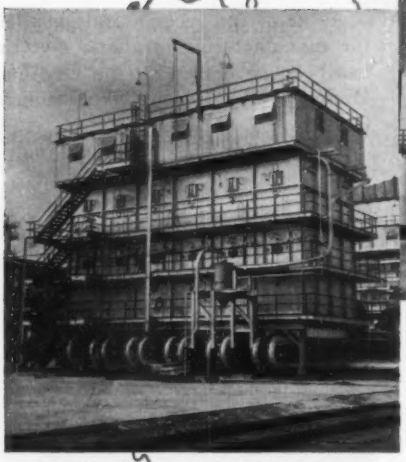
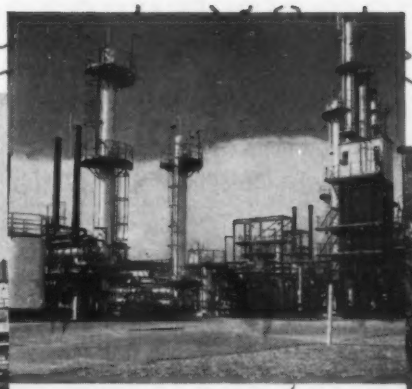


One of two 15 million cubic feet per day Girdler hydrogen reformers at a Delaware refinery.



Girdler hydrogen plant, a part of catalytic reformer installation in Gilsonite, Colorado.

Three large hydrogen plants have been built at widely separated locations for the Nitrogen Division of Allied Chemical Corporation.

HYDROGEN

In the last decade, most of the hydrogen plants installed in the United States and Canada have been built by Girdler.

This performance alone provides undisputed evidence of Girdler's ability and know-how and assures you of dependable design, engineering and construction. You can count on Girdler to help you when you're considering a new plant, or enlarging your present facilities for producing hydrogen or synthesis gases for ammonia, methanol, oxo-process, etc.

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Building . . .

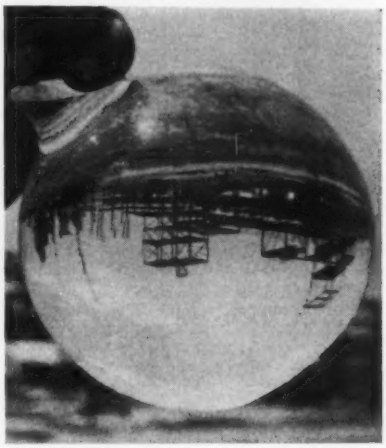
tion process licensed by Union Oil Co. of California will be used to convert distillate stocks to high-purity naphthalene. Installation of the hydrodealkylation facilities, scheduled for completion by mid-1962, will be made by Catalytic Construction Co. Designed capacity is 50 million pounds yearly.

California Oil Co. has awarded a contract to Badger Manufacturing Co. for the design, engineering and construction of a 30-million-pound-per-year phthalic anhydride plant at Perth Amboy, N. J. The plant, expected to be completed in the fall of 1962, will be operated by California Oil for Oronite Division of California Chemical Co. Design for the facility will be based on California Research Corp.'s fixed-bed process for phthalic production by oxidation of orthoxylene.

Olin Has New Method For New Glycerin Plant

A new and economical method for manufacturing synthetic glycerin has been developed by the Organics Division, Olin Mathieson Chemical Corp.

The corporation is building a multi-million-dollar plant to produce glycerin by the new method at its Doe Run complex in Brandenburg, Ky. Construction has already started, and the plant is expected to be in operation by April 1962. It will have a capacity of more than 40 million pounds per year.



Crystal ball effect: Future glycerin plant through a Florence flask.

The new method converts propylene oxide, through a new and highly efficient catalyst, to allyl alcohol, which is then converted to glycerin.

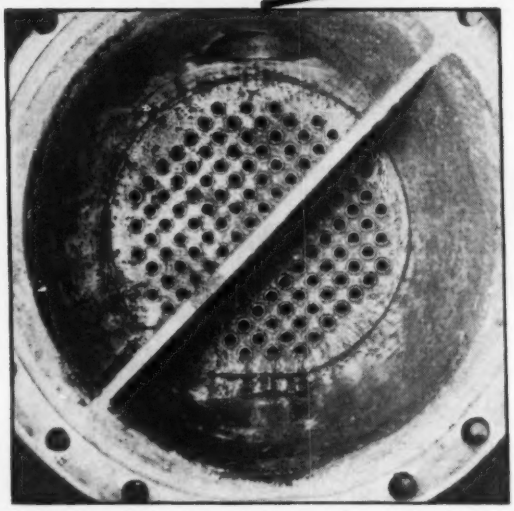
American Oil Co. has completed building crude facilities at its Casper, Wyo., refinery. The new unit increases the plant's capacity to 37,000 bpd. Bechtel Corp. handled construction. (HYDROCARBON PROCESSING & PETROLEUM REFINER, July 1961, Page 220).

E. I. du Pont de Nemours & Co., Inc., has begun building a methanol plant near Huron, Ohio, to produce about 30 million gallons annually. The venture is scheduled for completion in early 1963.

Shell Oil Co. has placed two gasoline plants on stream in the North Rincon field of Starr County, Texas, and has started to build a third unit in the Person field, Karnes County, Texas, near Kenedy. Delta Engineer-

Positive Control for Slime and Algae!

WRIGHT'S *New* TQC*



BEFORE the application of Wrico TQC, the tubes, shown above, were nearly closed with slime. Tuberculation of the water box occurred because a slime coating prevented the corrosion inhibitor from effectively contacting the metal. Three treatments with Wrico TQC killed the slime, allowing the corrosion inhibitor to be fully effective.

Where algae is concerned, a Texas refiner said, "Our towers have always had very bad algae problems although we've tried many products. We now apply Wrico TQC weekly and have no sign of algae."

Another use for Wrico TQC is in spray programs for preserving tower wood, as it is exceptionally effective against fungal growths.

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* *A new development of Wright Chemical Laboratories . . . patent applied for.*

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Building . . .

ing Corp. will build the facility, which will take 16 MMcfd of gas and recover some 13 tons of sulfur and sweetened residue gas daily. The two completed plants will process a total of 51 MMcfd of gas.

Standard Oil Co. of California will invest $10 million in the 20,000-bpd refinery it plans to build on the Kenai Peninsula, Alaska. Target date for completion is mid-1963, possibly by the end of 1962.

National Starch and Chemical Corp. has selected a site at Seadrift, Texas, for its proposed $4-million vinyl acetate plant. Construction will begin late this year, with completion scheduled late in 1962. Brown & Root, Inc., Houston, is the contractor. (HYDROCARBON PROCESSING & PETROLEUM REFINER, September 1961, Page 315.)

Enjay Chemical Company, a division of Humble Oil & Refining Co., plans to expand its line of solvents and chemical intermediates with new facilities at Humble's Bayway, N.J., refinery. Methyl isobutyl ketone will be the plant's principal product. The installation is expected to be completed and on stream by the middle of 1962.

Tidewater Oil Co. has let a contract to Information Systems, Inc., and C F Braun & Co. to conduct a modernization and automation engineering study of its Avon, Calif., facility. The scope of the study will be to determine short term and long range economic justification for refinery improvements in such areas as process engineering, instrumentation and control, maintenance and market analysis.

Panhandle Eastern Pipe Line Co. and National Distillers and Chemical Corp. plan to construct the world's largest helium plant at Liberal, Kan. The plant, designed to produce 1 billion cubic feet of helium per year, will be owned by National Helium Corp., a firm set up by the two companies. Construction is scheduled to start in mid-1962 with completion in about two years.

Heyden Newport Chemical Corp.'s Heyden Chemical Division has launched construction of a benzoic acid plant at Garfield, N.J. The facility's initial capacity will be 12 million pounds per year.

Houston Corp. is studying plans for a liquid hydrocarbon extraction plant near Brooker, Fla. The installation, which would begin producing in July 1962, will cost $6.25 million.

Tenneco Oil Co. is boosting capacity of its natural gas processing plant in Matagorda County, Texas, to 90 MMcfd with increased production of de-ethanized product.

Celanese Polymer Co. plans to put its polyacetal plant at Bishop, Texas, in operation January 1, 1962. Initial capacity, which is expected to be increased 10 times by 1970, will be 20 million pounds per year.

Goodrich-Gulf Chemicals, Inc., will increase capacity to produce cold styrene-butadiene rubber by approximately 8 percent at its Institute, W. Va., plant. The expansion includes addition of polymerization reactors and related equipment. Work has

With today's tight construction schedules, installation time can often mean the difference between profit and loss. That's why, when time is a critical factor, more and more engineers specify SMITHCO Air Cooled Heat Exchangers. They know that installation time for SMITHCO Coolers is logged in hours and minutes instead of days.

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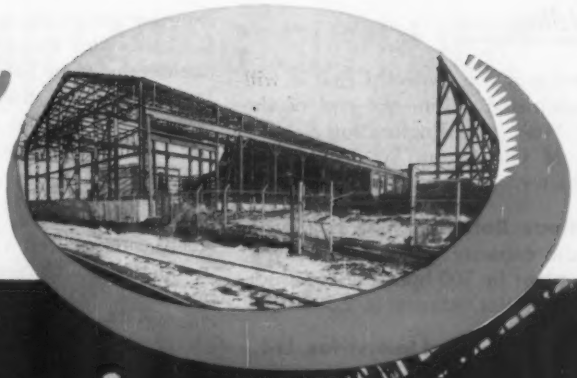

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Building . . .

started and it is expected that it will be completed before the end of the year. Muehlman Engineering Service, Inc., of Charleston, W. Va., is the contractor.

Gladieux Refining, Inc., is increasing the capacity of its Fort Wayne, Ind., plant by 700 bpd. Present crude charge at the refinery is 2,300 bpd.

Imperial Chemical Industries, Ltd., plans to build a 15,000-ton-per-year caprolactam plant at its Severnside, England, site. Process to be used is one developed by Emser Werke A.G./ Inventa A.G. of Switzerland. The process uses toluene as a raw material and yields ammonium sulfate as a by-product.

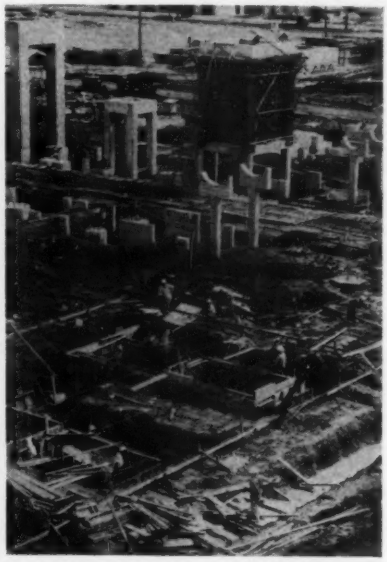
Donau Chemies, A.G., Vienna, Austria, has placed a plant on stream in the Bruckl Carinthia province to produce perchlorethylene and trichlorethylene. Cost of the unit is $500,000. The plant's output is mostly for exports.

Construction Underway On Philippine Refinery

Construction of a complete refinery for Filoil Refinery Corp. is underway at Manila, Philippines. Filoil is a Philippine oil concern, with Gulf Oil Corp. having a partial interest.

Procon, Inc., is doing the engineering and construction.

Most of the gasoline, middle distillate, fuel oil and other products



from the refinery are earmarked for the local Philippine market.

Included in the processing plan for the 10,000-bpd refinery are these units: Atmospheric and vacuum distillation, fluid catalytic cracking with gas concentration, Unifining-Platforming, middle distillate Unifining, catalytic polymerization, asphalt blending and Merox sweetening. Process design of all units was done by Universal Oil Products Co.

Ente Nazionale Idrocarburi will spend $48 million to build an 80,000-bpd refinery in Pavia province, at San Nazaro dei Burgondi, Italy. Completion date is set for 1963.

Rhodesia and Nyasaland officials have confirmed a 5-percent investment by Kuwait National Petroleum Co. in a refinery to be built at Umtali by American Independent Oil Co. and Shell and British Petroleum. The plant will be Rhodesia's first oil refinery.

Thai Oil Refinery Co., Ltd., has signed a multi-million-dollar agreement with the Thailand government

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Years of experience in engineering and fabricating of heat exchangers for the wide range of temperatures/pressures encountered in refining-petrochemical-natural gasoline plant processes enables EFCO to offer service-proved engineering design and guaranteed job rating. SunOlin Chemical Company is one of many process equipment users who are benefiting from EFCO's specialized experience and engineering efficiency.

This SunOlin Chemical Company installation of EFCO units, at SunOlin's new ethylene oxide production facilities under construction at Claymont, Delaware, is typical of the many high-pressure, high-temperature exchangers designed and fabricated by EFCO.

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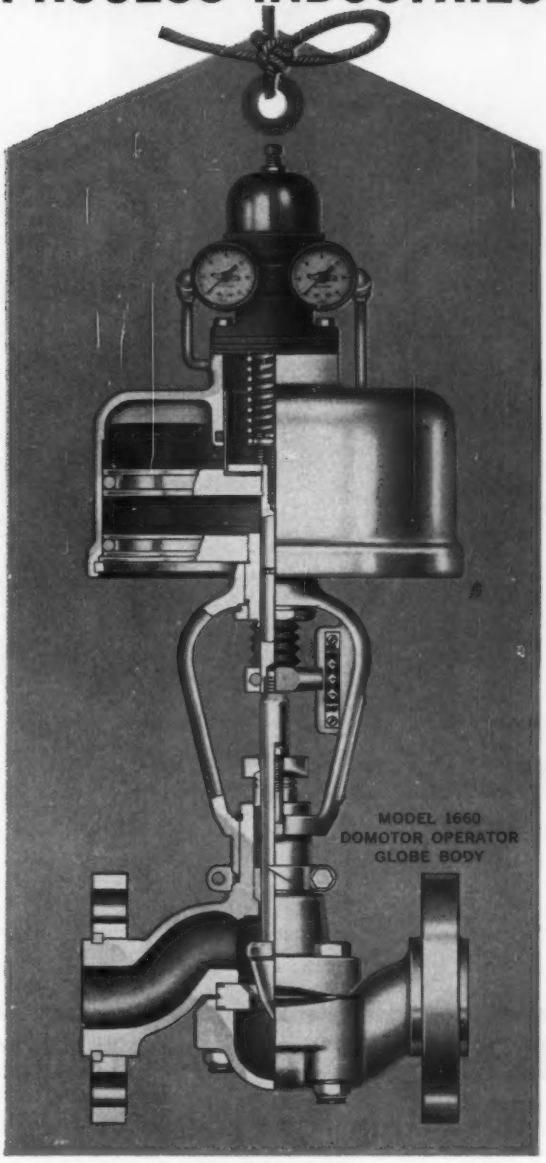
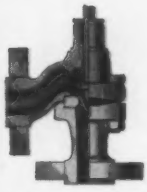
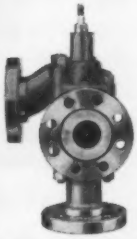
Annin control valves have been designed with the needs of the process industries in mind. The split body, single seat construction reduces body turbulence and erosion, gives longer life. The interchangeability of Annin valve components, the easily replaceable trim, the option of angle or 3-way bodies carried in stock for immediate shipment, simplifies your installation and maintenance problems. The flexibility in basic design cuts down on the valve parts inventory ordinarily required for a variety of plant applications. Another factor is the $1½ million in alloy body parts regularly carried in Annin stock, including a wide range of 300 series stainless steels, Hastelloys, Monel, Inconel, Durimet-20, and a variety of bronzes. If reduced valve inventory, design flexibility, and economical maintenance are factors in your operation, we suggest you investigate the advantages inherent in Annin process control valves.





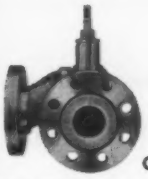
ANGLE BODY

For fluid problems involving solids in suspension, high viscosity fluids, and applications requiring special nozzle materials or design.



3-WAY BODY

Provides two horizontal line connections and an individual bottom vertical line connection. Sections may be rotated for convenience.



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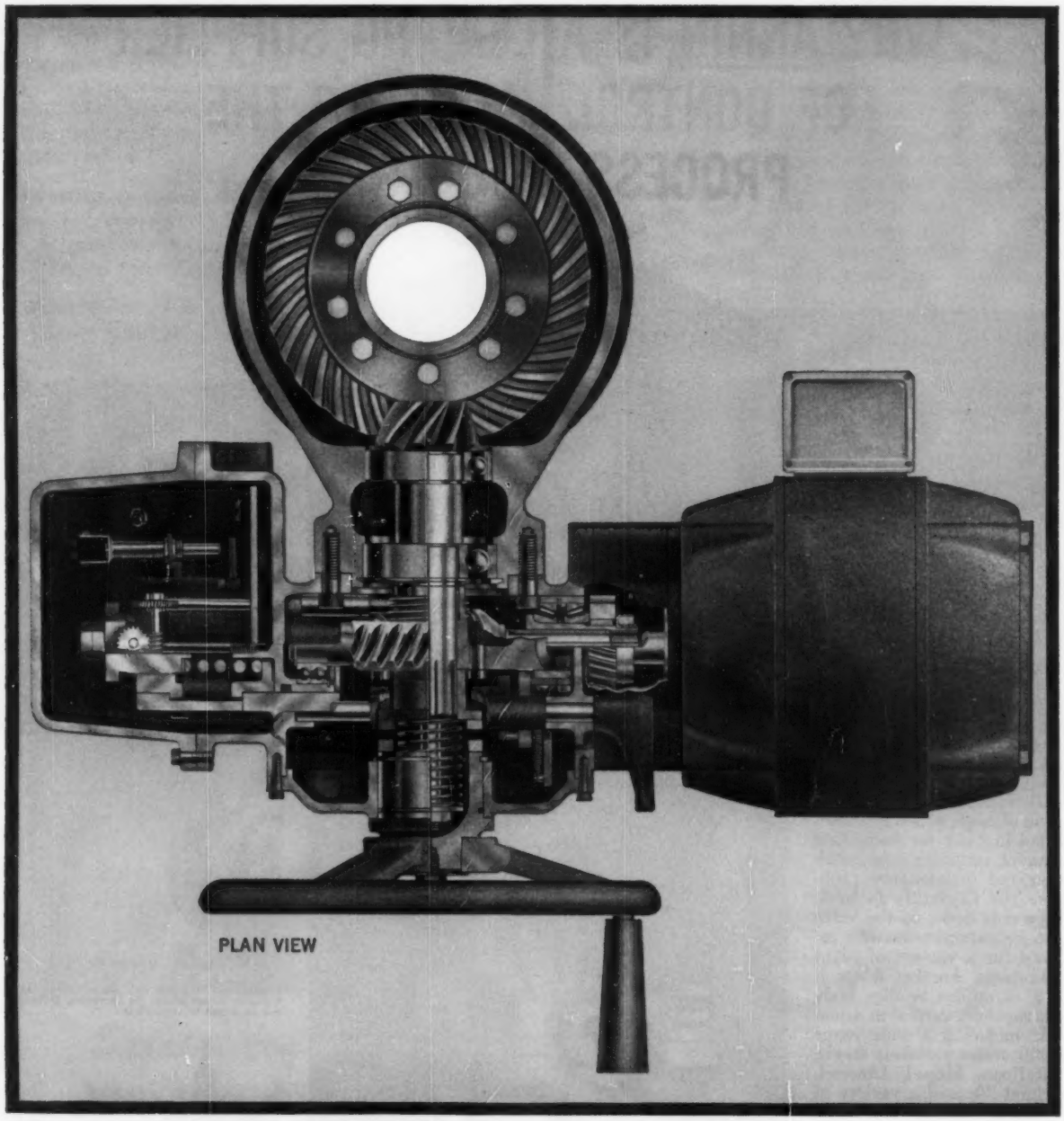

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"Crane Teledyne" was designed to provide torque only (thrust is taken on valve parts). This feature results in lower cost, smaller size and less weight than other operators with comparable output ratings.

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The motor operator is equipped to act as a gear-operated valve (4:1 ratio) in case of electrical emergencies. Available with push-button control or can be programmed for automated operation.

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Building . . .

for construction of a complete oil refinery. The 40,000-bpd plant will be engineered and built by Procon, Inc. Thai Oil Refinery, a private company of Thailand, has received backing from Shell Oil Co., Caltex and Standard-Vacuum Oil Co.

Imperial Oil Co., Ltd., will increase its 94,000-bpd refinery at Sarnia, Ont., by 16,000 bpd. Canadian Bechtel has received the contract, which covers expansion of distillation facilities. Total cost will be about $3 million.

Canadian-Montana Gas Co., Ltd., plans to construct an amine treating plant in the Black Butte-Aden area of Southeastern Alberta. The facility, to cost $279,620, will remove H_2S from 10 Mcfd of sour gas. Black, Sivalls & Bryson, Inc., will design the plant.

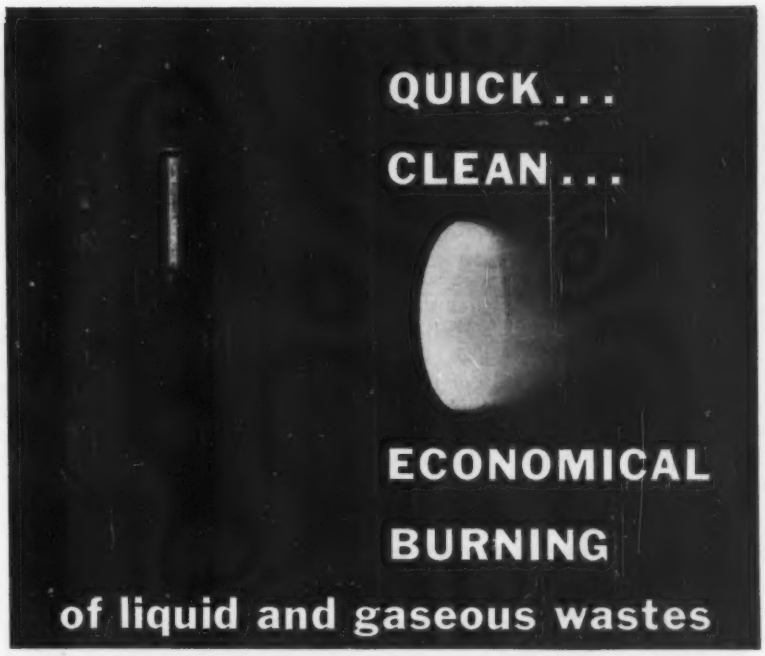
Montecatini is building a petrochemical plant at Ferrandina, Italy, to cost about $25 million. Among other products, the new facility will make 60,000 tons of plastics per year. The plant, which will use gas from Italy's Ferrandina gas field as its raw material, will go on stream in 1963.

Associated Octel Co., Britain's only tetraethyllead producer, will build a TML plant at Paimboeuf, France, along with Products Cimiques Ethyl-Kuhlmann. The facility is scheduled to be in operation about the end of 1962.

General Bussan is planning to build a 100,000-bpd refinery in Nagoya, Japan. The plant will produce 100,000 tons of ethylene, 30,000 tons of propylene and 15,000 tons of acetylene per year to be shipped to Mitsui Chemical and Toyo Koatsu, partners with General Bussan in a collective measure to make oils and chemicals.

Consumers Cooperative Refinery Co. has put a 2,700-bpd Unifiner-Platformer unit and a 5,000-bpd middle-distillate Unifiner into operation at its Regina, Sask., refinery. Universal Oil Products Co. designed and licensed the units.

Steelman Gas Co. plans to start building a gasoline plant outside Edmonton, Alta., in May or June 1962.



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Short, clean flame and compact size make the THERMAL Vortex Burner the perfect solution to many industrial waste disposal problems. Combustible liquid and gaseous wastes can be fed directly into the burner, eliminating the need for expensive, space-consuming incinerators. Combustion takes place quickly with an absolute minimum of smoke and odor. Where necessary, a conventional fuel may be fired to supplement the firing of the waste material. Simply and compactly designed, the THERMAL Vortex Burner can also become the nucleus of an efficient heat recovery system.

THERMAL'S laboratory facilities are available for trial burning of wastes. In addition, our staff of engineers is equipped to do complete turn-key designs to solve your waste burning problems. For further information, write for Bulletin #116.

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For more data on advertised products, use cards, last page.

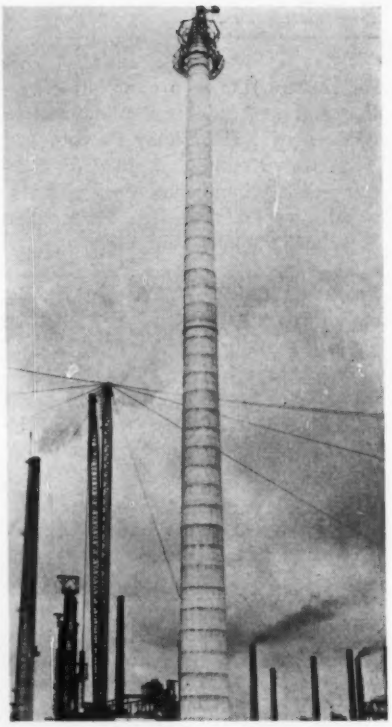
Building . . .

The $1.6-million plant is expected to begin operations in the fall of 1962. Initial capacity of the facility will be 70,000 Mcfd. (HYDROCARBON PROCESSING & PETROLEUM REFINER, September 1961, Page 319).

Shell Oil Co. plans to soak about $4 million into Singapore industries. New companies formed by Shell are Shell Lubricants Blending Co., Ltd., which will produce 100 or more grades of lubricating oil, and Shell Bitumin Manufacturing Co., Ltd., to make 75,000 tons yearly of bitumen.

British Petroleum Co., Ltd., will add a Ferrofining unit to its lubricants plant, Llandarcy refinery in Wales. The unit will enable lubricating oils to be manufactured without producing a solid waste by-product that requires disposal. The Ferrofining unit will have a throughput capacity of 3,500 bpd. Construction will begin early in 1962 with completion expected for the end of next year.

Egyptian Chemical Industries Co. has completed an expansion of ammonium calcium nitrate at its fertilizer plant at Aswan, Egypt. Daily output was boosted to 1,600 from 1,200 tons.



Nearly as high as the dome of St. Paul's Cathedral in London, this chimney towers 345 feet above Shell Nederland's Pernis plant near Rotterdam, Holland. It is designed to carry off flue gases far above the ground.

Ente Nazionale Idrocarburi has extended from $96 million to $152 million in credit to the Indian government, including an allotment for certain hydrocarbon processing installations: Complete refinery, 100,000-ton-per-year lube oil plant, LPG facilities, and a gas fractionation plant.

Standard-Vacuum Oil Co. has gained an additional 25 percent in a new Japanese refining company with completion of a 35,000-bpd plant at Kawasaki, Japan. Stanvac presently owns 50 percent of the firm with General Bussan Kaisha.

Empresa Colombiana de Petróleos (Ecopetrol), the national petroleum entity of Colombia, has awarded a lump-sum contract to The M. W. Kellogg Co. for an expansion-modernization program at its Barrancabermeja, Colombia, refinery. The project, scheduled for completion in the fall

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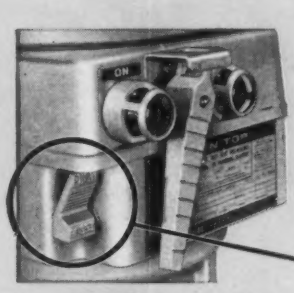

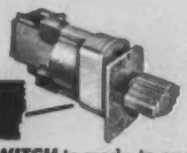

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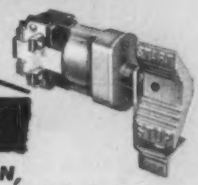

NEW! ***PUSHBUTTON,*** **like the selector switch, features one-piece construction for easy installation. Heavy-duty contacts and rugged mechanism assure long life.**

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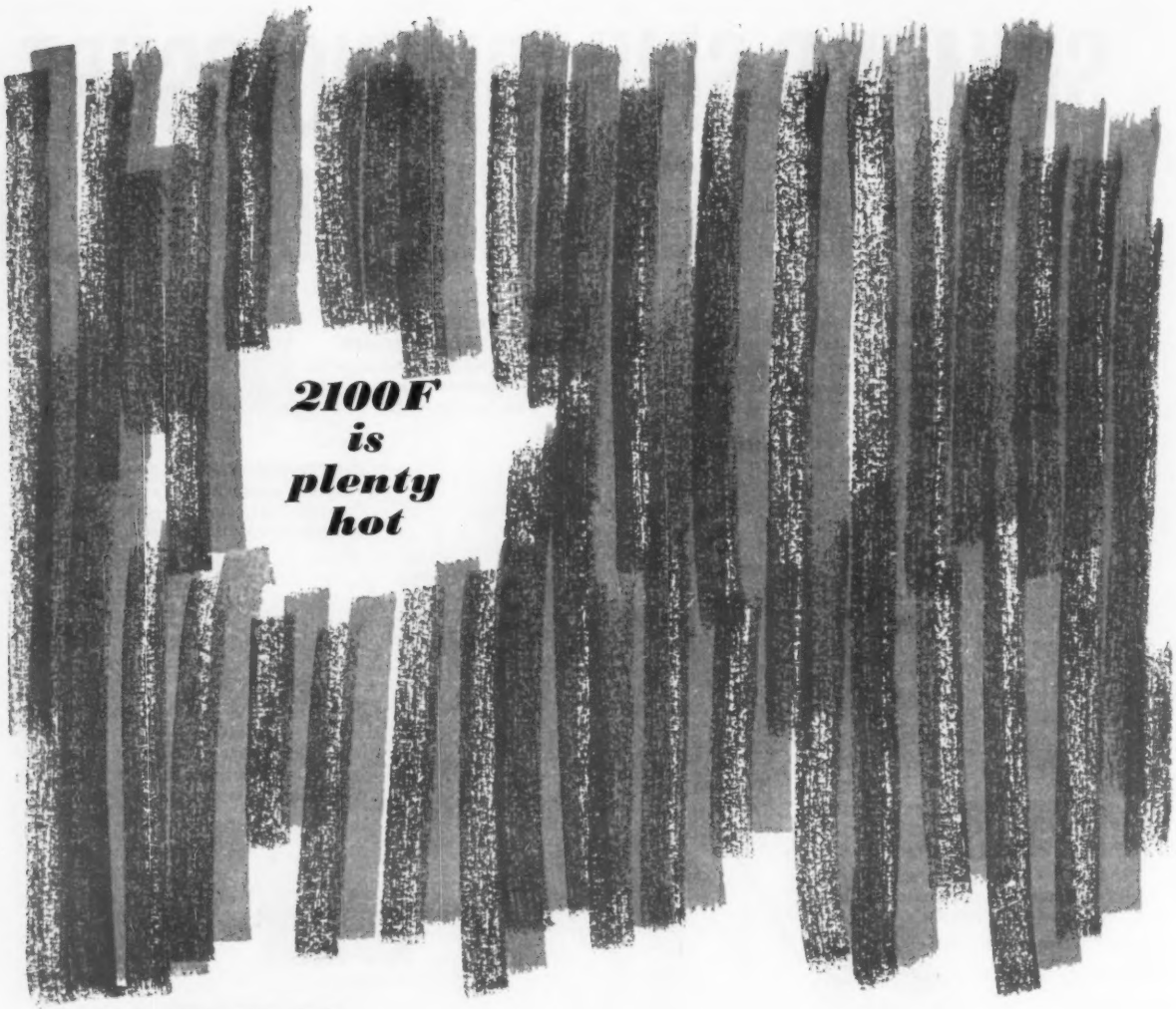

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Building . . .

of 1962, will include a 9,150-bpd vacuum distillation unit and a phenol extraction unit designed to produce a wide range of lube oil and grease blending stocks. In addition, Kellogg will design and erect a deisopentanizer unit and a stabilizer unit to process both natural gasoline and gasoline produced by the refinery.

Kohle-Oelchemie G.m.b.H. is delaying plans to construct a $25-million plastics complex in West Germany. Reason: Large investments planned by other plastics producers. Kohle-Oelchemie is joint venture of Deutsche Erdoel, Farbwerke Hoechst and Mannesman, steel pipe company.

Nihon Gas Kagaku Kogyo K.K. has given Chemical Construction Corp. a contract to redesign a urea plant at Niigata, Japan. Capacity of the plant will be raised 77 tons per day.

Iran's Abadan refinery will get a new Platformer, the largest single unit installed at the plant since the Iranian oil consortium was set up seven years ago. Fluor Corp.'s British and Dutch subsidiaries will build the unit, which is set for completion in April 1962. Cost of the project is estimated at $10 million.

HIAG Werke has placed Austria's first methanol plant on stream. Previously, Austria depended entirely on imports for their methanol needs. The new plant has an annual capacity of 11,025 tons.

Caltex Oil Co.'s new refinery to be built at Frankfurt, West Germany, will have 6,450 bpd of Isocracking capacity. The Isocracker will be the only gas-oil cracking facility in the plant. Process design engineering on the unit is being handled by California Research Corp.

Petroquimica Argentina, S.A. has completed financing arrangements for a large part of its $72-million petrochemical complex to be built at San Lorenzo, Argentina. A purchase agreement covering $18.5-million, five to ten-year Class B subordinated debentures has been signed at Chase International Investment Corp. The plant is to include a catalytic re-

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Building . . .

former and units to make benzene, styrene, butadiene and aviation-grade alkylate, SBR rubber, cis-polybutadiene and intermediate products including carbon black.

Golden Eagle Refining Co. of Panama is putting its long pending plan to build a refinery at Portobelo into motion. The 55,000-bpd plant is scheduled for completion in late 1962. Also, a related petrochemical plant will go up along with the refinery to produce about 3,400 bpd of benzene and toluene.

Hooker Chemical Corp. has received approval from the Argentine government on its investment in Duranor, Industrias Quimicas Sociedad Anonima Industrial y Comercial, an Argentine affiliate formed to produce phenol. The Duranor plant is being built at Rio Tercero, some 450 miles northwest of Buenos Aires. Daily capacity will be 25 tons of phenol.

Ente Nazionale Idrocarburi has started work in Southern Italy on a petrochemical complex that will cost about $160 million. The facility, which is expected to be finished in the second half of 1962, will use methane discovered at Ferrandina.

Spain is in line to get a $20-million petrochemical complex to be constructed at Puertollano. The big deal involves Instituto Nacional de Industria, Spanish government agency, Imperial Chemical Industries, Royal Dutch Shell Group, Montecatini, Phillips Petroleum, two Spanish firms, Union Espanola de Explosivos and Gros, and Farbewerke Hoechst. Plans call for petrochemical units to encircle a 1.2-million-ton-per-year refinery to be built at Puertollano by INI for $30 million.

Pakistan plans to have its first high-pressure polyethylene plant on stream by the end of 1963. The project includes units to make ethylene, high-pressure polyethylene and finished products. Yearly capacity will be 5,000-6,000 pounds of polyethylene granulate.

Esso Standard Eastern has received the green light from the Indian government to build a petrochemical plant at Trombay. Initial capacity of the plant will be 100,000 tons per year, including ethylene, propylene, benzene and other chemicals. Naphtha feedstock will come from Esso's refinery at Trombay.

Assam Gas Co. in India has had its proposal to build a gas processing plant approved by the government. The facility will produce 856,000 pounds of propane, 780,000 pounds of isobutane, 343,000 pounds of ethane and 500,000 pounds of pentane annually. To be completed by mid 1963, the plant will use 40 MMcf of gas per year.

N. V. Chemische Industrie Synres, 50 percent owned by Allied Chemical Co., has awarded a contract to Badger N. V. for the design, engineering and construction af a phthalic anhydride plant at Hoek van Holland, the Netherlands. The project is expected to be completed during the fall of 1962.

Societe Industrielle Belge des Petroles has given Foster Wheeler Corp. a multi-million-dollar contract to handle an expansion project at its Antwerp, Belgium, Kruisschans refinery. New units include a 100,000-bpd crude distillation unit with LPG recovery facilities; a 10,000-bpd desulfurization unit using a Shell Oil Co. process; a 11,500-bpd UOP Unifiner-

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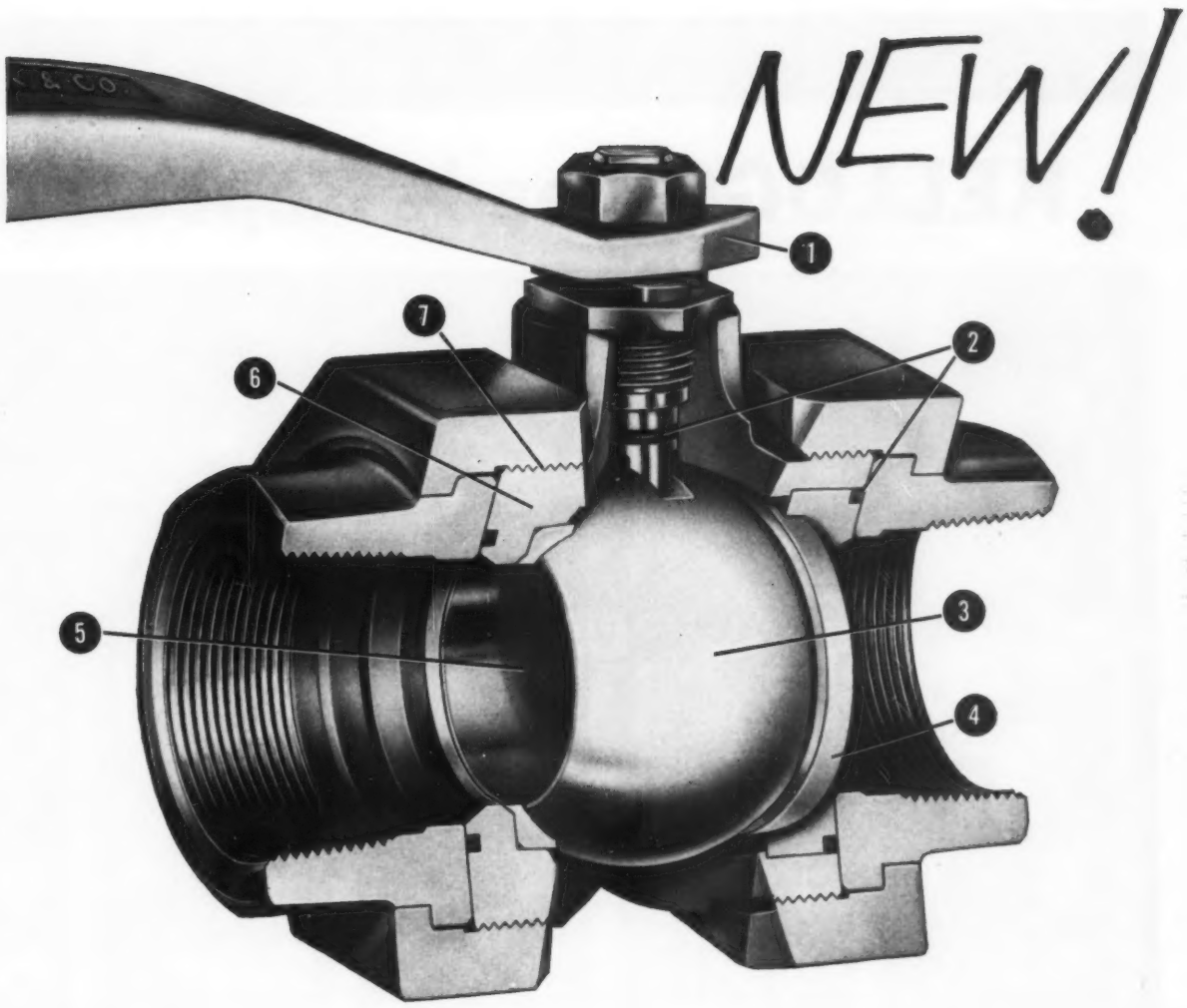

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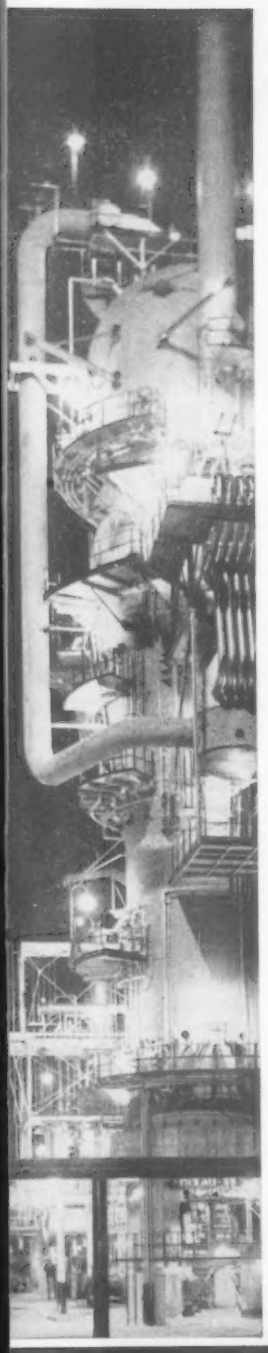

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Kellogg's leadership in cat cracking is based upon a continuing program of design improvement. Both in the company's New York engineering offices and Jersey City laboratories, Kellogg specialists have achieved numerous improvements in product quality and yields while reducing investment, utility, and catalyst costs.

The latest developments in Kellogg's Orthoflow design permit use of greater variety of feedstocks and provide improved product distribution, more operational flexibility, and still higher yields of gasoline and lower yields of coke—all with less capital investment and upkeep than ever before.

Whatever your cat cracking needs . . . modernization . . . expansion . . . completely new facilities . . . Kellogg welcomes the opportunity to discuss how it can work to your economic advantage.

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COMPANIA KELLOGG de VENEZUELA, CARACAS
COMPANHIA KELLOGG BRASILEIRA, RIO DE JANEIRO

LOCATION	TOTAL THRUPUT BPD
Edmonton, Alberta	3,784
Ponca City, Oklahoma	24,480
Sarnia, Ontario	14,027
Gelsenkirchen, Germany	5,000
Amarillo, Texas	9,706
Sisak, Yugoslavia	3,332
Toledo, Ohio	17,705
Smiths Bluff, Texas	26,625
Philadelphia, Pennsylvania	45,000
Clarkson, Ontario	45,000
Kwinana, Australia	12,500
St. Boniface, Manitoba	9,837
Enid, Oklahoma	19,330
Delaware City, Delaware	101,800
Yorktown, Virginia	30,618
Puerto La Cruz, Venezuela	14,290
Mataripe, Brazil	20,493
Vancouver, British Columbia	13,500
Montevideo, Uruguay	7,000
Concon, Chile	14,400
Mendoza, Argentina	18,783
Borger, Texas	34,830
Texas City, Texas	95,160
Istanbul, Turkey	9,380
Baton Rouge, Louisiana	17,000
Baytown, Texas	14,700
Baton Rouge, Louisiana	15,500
Dominques, California	18,700
Aruba, Netherlands W.I.	15,000
Baltimore, Maryland	15,000
Wood River, Illinois	17,050
Port Arthur, Texas	22,000
Lake Charles, Louisiana	23,400
Parco, Wyoming	9,350
Lake Charles, Louisiana	16,286
Texas City, Texas	17,050
Port Arthur, Texas	17,050
Wood River, Illinois	17,600
Salt Lake City, Utah	14,500
Lake Charles, Louisiana	17,435
Sarnia, Ontario	29,000
Baton Rouge, Louisiana	15,500
Baytown, Texas	15,500
Wood River, Illinois	10,000
Whiting, Indiana	20,000
Wilmington, California	16,275
Dinslaken, Germany	10,000
Philadelphia, Pennsylvania	21,030
Casper, Wyoming	6,000
Whiting, Indiana	67,710
Lockport, Illinois	22,400
Sugar Creek, Missouri	20,000
Heath, Ohio	5,000
Montreal East, Quebec	30,358
Tulsa, Oklahoma	16,200
East Chicago, Indiana	46,500
Casper, Wyoming	8,000
Port Arthur, Texas	90,000
Montreal, Quebec	11,000
Toledo, Ohio	30,635
Eagle Point, New Jersey	33,250
West Tulsa, Oklahoma	19,523
Cincinnati, Ohio	19,375
El Dorado, Kansas	22,810
Montreal East, Quebec	21,588
Lawrenceville, Illinois	35,150
Port Arthur, Texas	67,093
Winnipeg, Manitoba	3,740
Grangemouth, Scotland	13,000
Llandarcy, Wales	17,930
Isle of Grain, England	13,500
Philadelphia, Pennsylvania	63,750
La Plata, Argentina	26,165
Port Arthur, Texas	68,000
Gonfreville, France	31,370
Campana, Argentina	14,040

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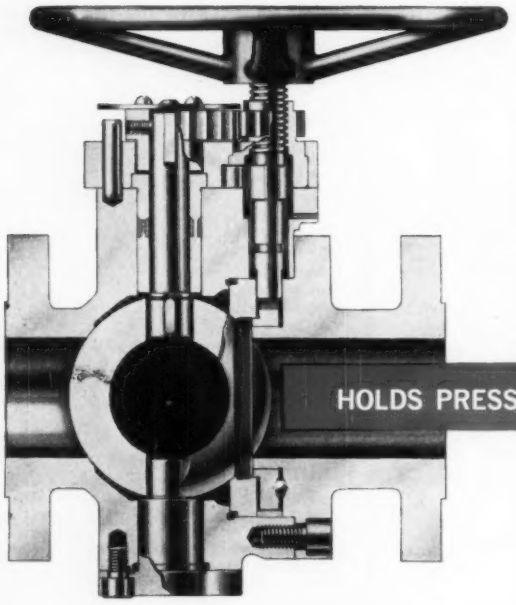

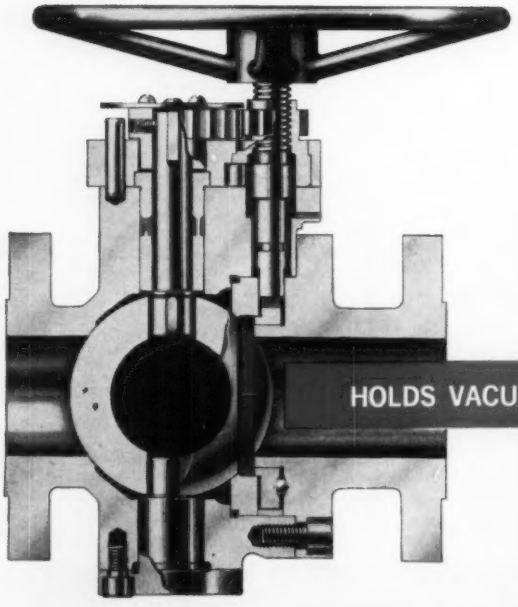

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Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

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Building . . .

Platformer; and a hydrogen sulfide absorption and sulfur recovery unit having a 60-ton-per-day capacity. Project completion is scheduled for spring 1963.

Standard-Vacuum Oil Co. has begun building a $17-million refinery in the Federation of Malaya at Port Dickson near Kuala Lumpur. It will be the company's first refinery on the mainland of Southeast Asia. Startup date for the new plant, which will process 20,000 bpd of crude, is set for early 1964. The project is being handled by Standard-Vacuum Refining Co. of Malaya, Ltd., manufacturing subsidiary of Standard-Vacuum.

Nippon Oil Refining Co. expects to more than double its present refining capacity with a $40-million loan from Caltex, its 50-percent owner. Nippon will construct a 100,000-bpd plant to cost an estimated $76 million. The new refinery is set to go on stream in the fall of 1963 at Negishi, Yokohama, Japan.

Gelsenberg Benzin A. G. is proceeding with plans for its Bavarian refinery by acquiring an option on a site near Neustadt, 20 miles from Ingolstadt. The plant, to have a daily capacity of 40,000-50,000 bpd, is set for completion by 1964.

Teikoku Oil Co. expects to become part of Japan's fast growing oil refining industry by October 1962, with completion of a 3,000-bpd plant in Niigata prefecture. The plant will be built by Teiseki Topping Plant Co.

Societe des Elastomeres de Synthese plans to build a cis-polybutadiene plant in France to produce 22,050 tons per year. The project, to be completed at the end of 1963, is the result of a pooling of patents by Goodrich-Gulf Chemicals, Shell Chemical and Montecatini. Soc. des Elastomeres will have exclusive license in France for Shell, Goodrich-Gulf and Montecatini patents in the first few years of production.

Commonwealth Oil Refining Co., Inc., is moving into petrochemicals with the construction of a $6.5-million plant adjacent to its refinery at Ponce, Puerto Rico. Building will

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Measurement of concentration to one gas component in a mixture of gases, utilizing sensitive filaments as the detector. Applicable for determination of: H_2 in O_2. N_2 mixtures; Argon in air; hydrogen purity; CO_2 in flue gas, etc.

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For more data on advertised products, use cards, last page.

Why a Steam Trap Has To Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

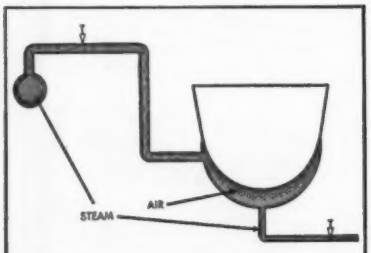


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

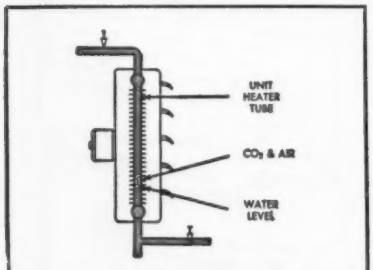


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates the situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

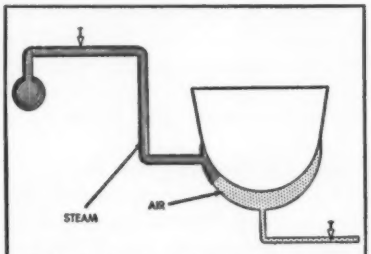


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

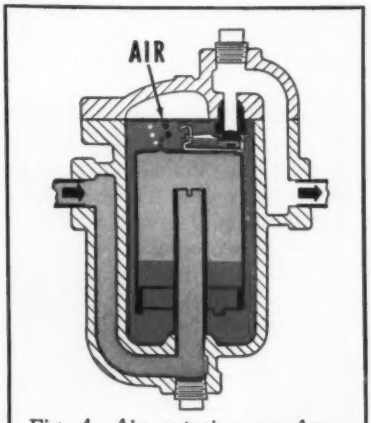
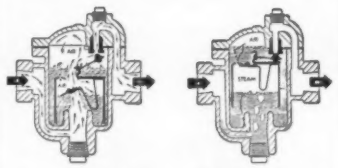


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

Open Float with Thermostatic Vent

Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

* * *

The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8523 Maple Street, Three Rivers, Michigan.

ARMSTRONG STEAM TRAPS

See our Catalog in Refinery Catalog.

Building . . .

begin in January 1962 with on stream date set for January 1963. The facility will produce 50 million pounds per year of naphthalene and other petrochemicals including aromatics.

Shell Oil Co. and British Petroleum Co. have awarded Procon (Great Britain), Inc., a contract for a 40,000-bpd refinery in Kenya. The plant is slated to go on steam by the end of 1963.

Petroleos Mexicanos plans to construct two refining units on Mexico's west coast at a cost of $50 million. The two installations: A 50,000-bpd refinery at Mazatlan and a 30,000-bpd coking plant near Tijuana, at Rosarito Beach. The plants will be partly financed by a $34-million loan from French banks.

Nippon Shokubai Kagaku Kogyo plans to double its production of ethylene oxide and ethylene glycol at its Khidori-cho, Japan, plant. At the completion of new facilities in December 1962, the company will be making 10,000 tons of ethylene oxide and 7,000 tons of ethylene glycol yearly.

B. F. Goodrich Chemical Co. has begun commercial production at its vinyl resin plastics plant near Melbourne, Australia. The $3.5-million facility will be operated by B. F. Goodrich-CSR Chemicals Pty., Ltd., a company formed by the Cleveland firm and CSR Chemicals Pty., Ltd., Sydney, Australia.

Delhi Cloth & General Mills Co., Ltd., has received a license from the government of India to erect a plant at Kotah in Rajasthan to produce 20 tons daily of polyvinyl chloride.

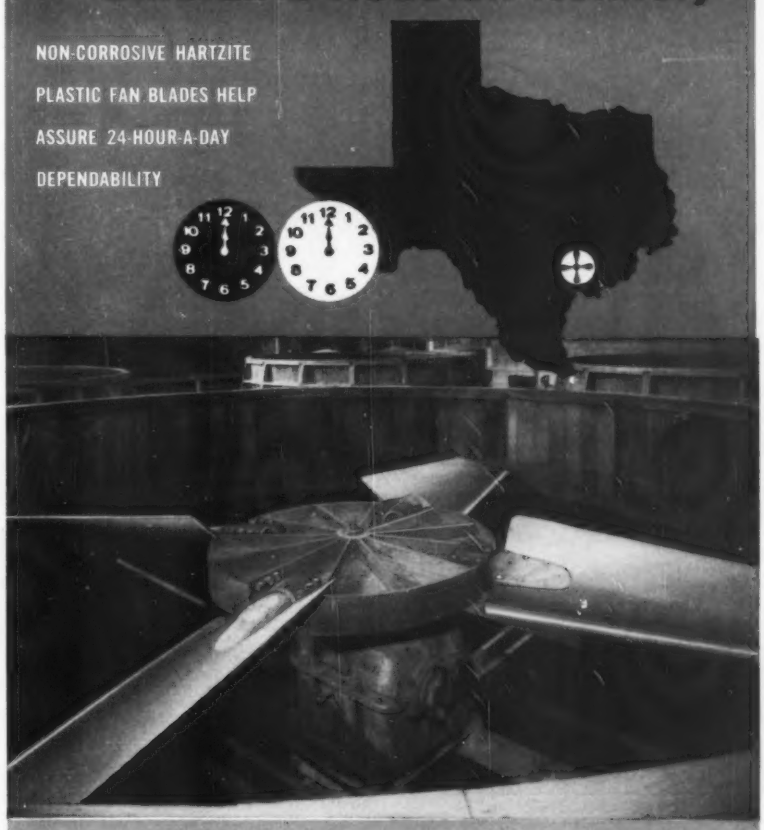
Union Carbide of India, Ltd., plans to expand its polyethylene capacity from 6 to 20 million pounds yearly. The expansion program includes setting up a naphtha cracker for producing ethylene and propylene.

South African Petroleum Refineries Pty., Ltd., has awarded a construction contract to Foster Wheeler, Ltd., for a 70,000-bpd refinery at Reunion Rocks, South Africa. The

Hartzell REPORTS

on Cooling Tower Fans from Sinclair's Houston Refinery

NON-CORROSIVE HARTZITE PLASTIC FAN BLADES HELP ASSURE 24-HOUR-A-DAY DEPENDABILITY



At Sinclair's Houston Refinery, six 16-foot cooling tower fan blades made of non-corrosive Hartzite plastic have been delivering 24-hour-a-day dependability for over five years.

Exclusive Hartzite plastic has been proved on thousands of installations in chemical plants, refineries and power plants to be the material most resistant to corrosion and mechanical damage. It absorbs vibration and its strength is far greater than required to withstand normal stresses. In addition, adjustable-pitch, tapered blades are heavily reinforced.

Hartzell designs and manufactures cooling tower and heat exchanger fans to cover every application. It will pay you to get all the facts from your nearby Hartzell representative, or, write direct for your copy of Bulletin A-111C.

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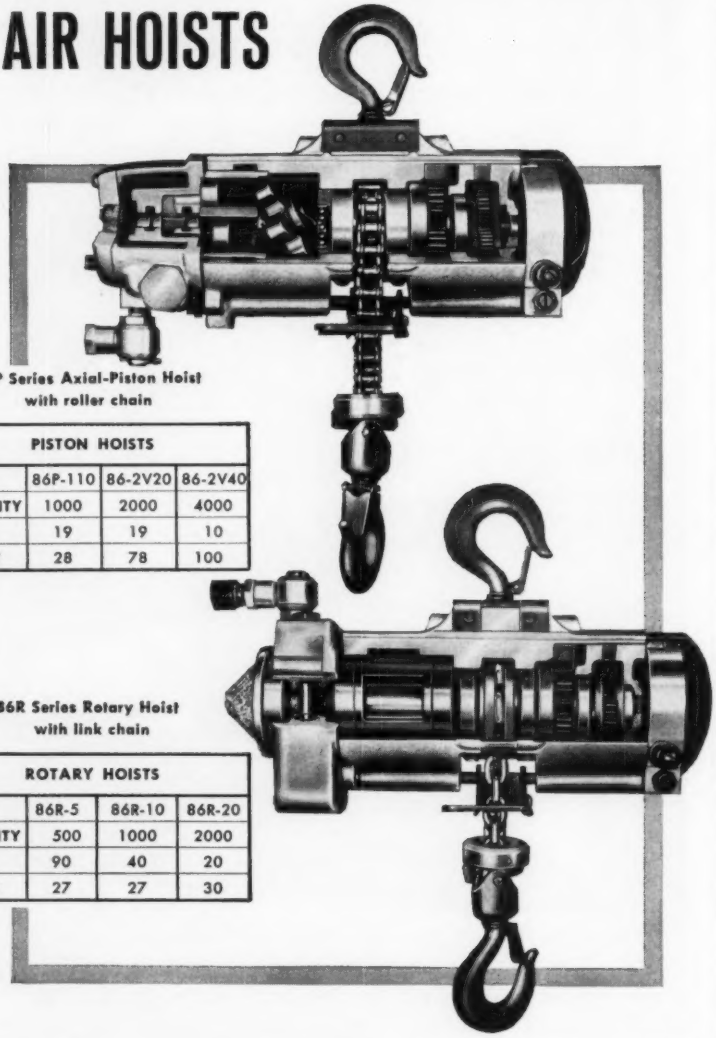

86P Series Axial-Piston Hoist with roller chain

PISTON HOISTS			
MODEL	86P-110	86-2V20	86-2V40
CAPACITY	1000	2000	4000
SPEED	19	19	10
WEIGHT	28	78	100

86R Series Rotary Hoist with link chain

ROTARY HOISTS			
MODEL	86R-5	86R-10	86R-20
CAPACITY	500	1000	2000
SPEED	90	40	20
WEIGHT	27	27	30

To help you achieve maximum efficiency and flexibility in lifting loads to 4000 lb., Gardner-Denver—*and only Gardner-Denver*—offers lightweight, overhead air hoists in both axial-piston and rotary motor types.

"Work Horse" axial-piston hoists provide rugged, dependable operation where load *control* is the important factor.

"Race Horse" rotary air hoists are designed for use where the combination of speed and ruggedness is the major consideration.

Both types provide variable speed, spark-resistant operation, powerful brake and precise control. Popular models available from 150- to 4000-lb. capacity.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

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International Offices: Buenos Aires, Argentina; Artarmon, N.S.W. Australia; Brussels, Belgium; Rio de Janeiro, Brazil; Santiago, Chile; Barranquilla, Colombia; Lima, Peru; Ndola, N. Rhodesia; Salisbury, S. Rhodesia; Johannesburg, Transvaal.

Building . . .

refinery, slated to go on stream by January 1, 1964, will include these units: Crude distillation, hydrodesulfurization, platforming, sulfur recovery, sour water stripper and LPG stripper and amine treater.

Reichhold Chemicals, Inc., will spend $3.2 million to expand its operations in Mexico. The firm's Mexican subsidiary, Reichhold Chemicals de Mexico, S.A., will build four plants near Mexico City to make phthalic anhydride, formaldehyde, plasticizers and synthetic resins.

The Borden Chemical Co. has completed a new resin plant at Pilar, Argentina, to make 13 million pounds of formaldehyde and 6.6 million pounds of urea and both phenolic and resorcinol resins annually.

Allied Chemical Canada, Ltd., plans to construct a multi-million-dollar plant in Ontario to supply diisocyanates to the Canadian market. This will be the first such facility in Canada. Completion is slated for late 1962.

Toyo Koatsu Industries and Miike Gosei Chemical Industry are forming a new company in Japan to produce polystyrene. The firms are negotiating with Cosden Petroleum Corp. for technical assistance. Projected capacity for the project shows annual output will be 11,400 tons of polymers in 1964.

Rheinische Olefinwerke, jointly owned by Badische Anilin & Soda Fabrik and Deutsche Shell, has invested $112.5 million in six plants increasing ethylene capacity to 150,000 tons yearly and epoxy resin production from 3,000 tons to 5,000 tons per year.

Mitsui Petrochemical Co. plans to increase its cumene capacity in Japan. Mitsui, presently producing phenol and acetone via the cumene process, will expand phenol to 3,000 tons per month and acetone 1,800 tons monthly.

Burapha Setthakit Co. (Eastern Economic Development Co.) plans to build a second refinery in Thailand with a capacity of 5,000 bpd.

Harbison-Walker Refractories
FOR MAXIMUM DURABILITY IN PETROLEUM REFINING AND PETROCHEMICAL APPLICATIONS

H-W CASTABLE REFRACTORIES

FOR THE SPECIAL REQUIREMENTS OF THE OIL REFINING AND PETROCHEMICAL INDUSTRIES

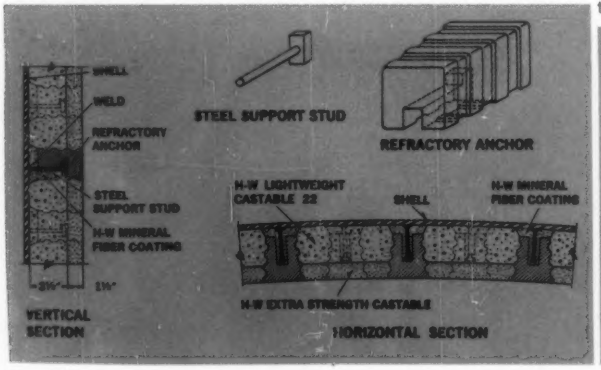
BRAND	APPROXIMATE SERVICE LIMIT	PROPERTIES	TYPICAL APPLICATIONS
H-W EXTRA STRENGTH CASTABLE	2400°F.	Unusually high strength and resistance to abrasion. The strongest by a wide margin, among all the regular castables. May be poured or gunned. 114 lbs. of dry material required per cu. ft. of construction.	Lining catalytic cracking vessels and catalyst feed lines, doors and sub-bottoms of various types of furnaces, patching worn brickwork and for coating interior walls of furnaces.
H-W HARCHROME AND *H-W HARCHROME G	2600°F.	High strength and resistance to abrasion. 166 lbs. of dry material required per cu. ft. of construction.	For lining cyclones and feed lines in catalyst units.
H-W CASTOLAST AND *H-W CASTOLAST G	3200°F.	An extremely high purity low-iron refractory concrete consisting of accurately sized tabular alumina, blended with low-iron calcium-aluminate binder. Develops high strength and is highly resistant to corrosive gases and reducing atmospheres. 143 lbs. of dry material required per cu. ft. of construction.	Linings for Butadiene reactors, reformer vessels, hot cyclones and catalyst feed lines, and for high temperature burner blocks.
H-W HARCAST and *H-W HARCAST BF	2800°F.	Highly resistant to reducing conditions with a ferric oxide content of less than 0.5% which adequately meets the specifications of petroleum companies. For use where platinum catalysts are employed. Exceptional strength at all temperatures up to its service limit. 123 lbs. of dry material required per cu. ft. of construction.	For severe erosion areas such as regenerator cyclones and catalyst feed lines.
H-W LIGHTWEIGHT CASTABLE-EXTRA STRENGTH	2300°F.	Combines good insulation and unusual strength. Has a fired density of 80 to 85 pounds per cubic foot, but is stronger than some fireclay or high-alumina castables of the usual densities.	For use as the primary lining even in furnaces where the lining is subjected to abrasion of moderate intensity.
H-W LIGHTWEIGHT CASTABLE 22	2200°F.	Combines light weight and strength to the utmost degree. Has thermal conductivity of approximately 35% of that of fire brick. 50 lbs. of dry material required per cu. ft. of construction.	Refinery vessel linings, ducts and breechings, boiler wall backing and tube decks, air preheater linings, furnace walls, roofs and doors.
H-W LOW-IRON LIGHTWEIGHT CASTABLE 22	2200°F.	Has exceptionally low ferric oxide content of less than 0.5%. Excellent strength. 50 lbs. of dry material required per cu. ft. of construction.	Refinery vessel linings where material must meet low iron specifications.
H-W CC LIGHTWEIGHT CASTABLE	2300°F.	Combines light weight and high strength, low heat conductivity and desirable refractoriness. 85 lbs. of dry material required per cu. ft. of construction.	Oil refinery units, one shot linings, ducts and breeching, boiler wall backing and tube decks, furnace walls, roofs and doors.

Weights shown are approximate, based on casting in place, and for gun applications are slightly higher.
***For gunning and trowelling applications where extreme erosion resistance is required.**

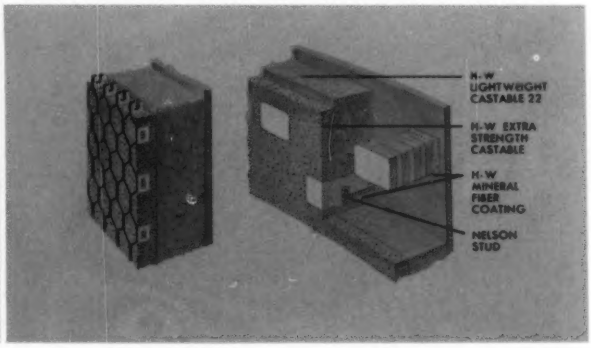
CASTABLE CONSTRUCTION FOR REFINERIES

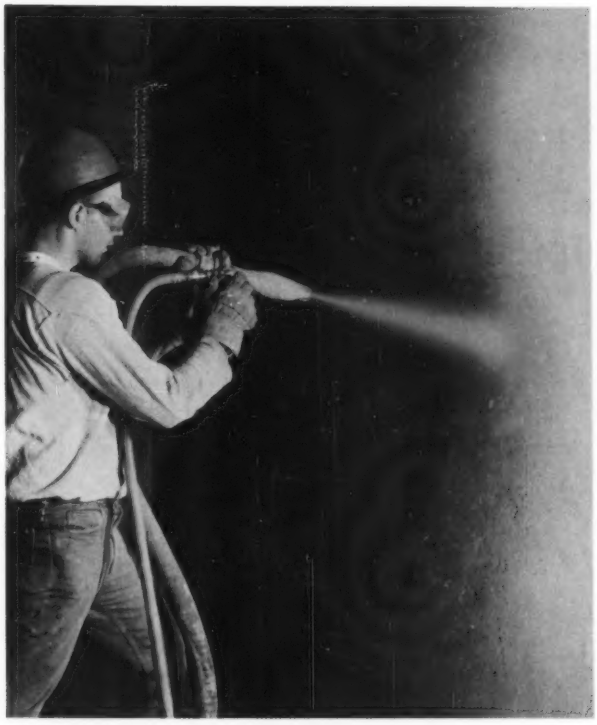
REFRACTORY ANCHOR AND TYPICAL ARRANGEMENT FOR MONOLITHIC LININGS IN CATALYTIC CRACKING UNITS

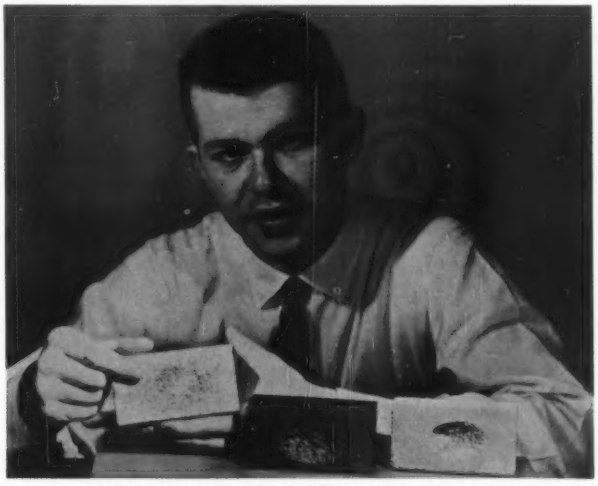
Illustration shows H-W Lightweight (Insulating) Castable 22 next to the regenerator shell with H-W Extra Strength Castable superimposed in hex steel for working lining.



Typical arrangement of refractory anchor method for monolithic linings in catalytic cracking units. Eliminates hex steel for support, resulting in much faster and lower cost installation and eliminates tearing and peeling from expansion-contraction strain.



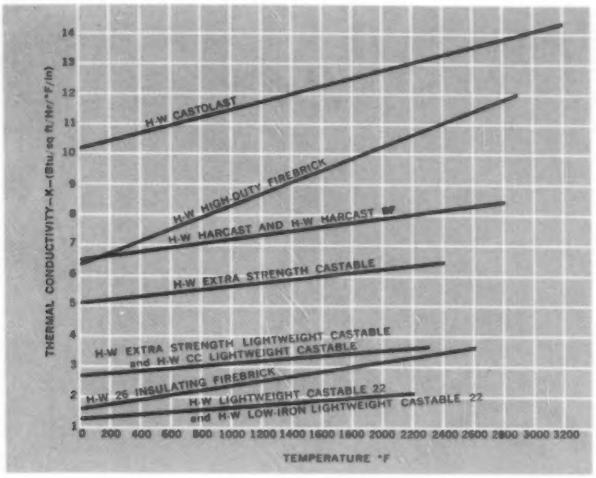




H-W Castolast G | Bonded Silicon Carbide Brick | Standard High Strength Castable

G SERIES CASTABLES SHOW ABRASION RESISTANCE COMPARABLE WITH SILICON CARBIDE BRICK

In a laboratory test which blasts refractory castable specimens with air-entrained silicon carbide grit, both H-W CASTOLAST G and HARCHROME G showed resistance to abrasion loss of the same order as fired, bonded silicon carbide brick. Resistance was more than 10 times that of castables normally classed as "high strength" or "erosion resistant" types. Even after heating the specimens to 1000 or 1500°F, the strength differential over normal high strength castables remained. This great hardness of G-Series castables, coupled with other good physical properties, has resulted in outstanding applications in the petrochemical field. Write for directions for preferred installation techniques.



REFRACTORY BRICK

FIRECLAY REFRACTORIES

The various brands of Harbison-Walker fireclay brick meet the requirements for each individual class of refractory to the fullest extent. They have a wide range of physical properties, and possess utility for many different service requirements. Harbison-Walker fireclay brick are of the highest quality and workmanship and are widely regarded as standard for all kinds of furnace linings, and for all operating conditions for which fireclay brick are suited.

SUPERDUTY FIRECLAY REFRACTORIES

To meet the more exacting requirements of modern industrial furnaces, Harbison-Walker has developed brands of brick of the superduty fireclay type, namely, ALAMO, VARNON, BOONE, H-W SUPER-SAVAGE, KENMORE, H-W KALA, ZENITH and DEAN. These are superior to high-duty fireclay brick in refractoriness and most of the other important physical properties and in chemical composition.

HIGH-ALUMINA REFRACTORIES

Harbison-Walker high-alumina brands include all the commercial classes from 50% to 99% alumina. In certain of these brands the desired properties are obtained by using as raw material, the highest grades of diaspore clay or other aluminous minerals. In others, use is made of blends containing crystalline alumina or corundum. In each case, during manufacture, the brick are subjected to the particular heat treatment which will effect the most desirable mineral conversions to mullite and corundum. High-alumina brick of all the various classes are more refractory and more resistant to the corrosive action of vanadium oxide and alkalies of oil ash than are fireclay or kaolin brick, approximately in proportion to their content of alumina.

ACID-PROOF BRICK AND TILE

DURO and W-ACID acid-proof brick and tile are dense, vitreous and non-absorbent. They are strongly resistant to the action of all mineral acids, except hydrofluoric, as well as to organic acids and many other solvents. These brands of brick are well adapted for service in processes using temperatures as high as 2300°F. in conjunction with nascent gases and acid fumes. They have exceptionally high mechanical strength.

MORTARS, AIR-SETTING AND HEAT-SETTING

For any refractory fire brick construction the selection of the most suitable bonding mortar is as important as is the selection of the most suitable brick. The choice depends upon the service requirements, and the mortar selected should be compatible in refractoriness and other properties, with those of the refractory brick.

HARWACO BOND is an air-setting high temperature bonding mortar which is shipped in the wet form, ready mixed for use. Experience in the use of this mortar has proved the excellence of its workability. HARWACO BOND is recommended for use in laying fireclay, super-duty fireclay and high-alumina brick. In some applications it is used to advantage for laying SILICON CARBIDE brick.

PENSEAL is an air-setting high temperature bonding mortar having unusual plasticity. It is shipped ready-mixed in steel drums of 100 and 200 pound net weights. It has excellent workability and can be trowelled directly from the drum or made to a dipping consistency by adding water. PENSEAL has low shrinkage, good adherence, and long life in storage.

THERMOLITH is a highly refractory air-setting bonding mortar in dry form. It consists of finely ground chrome of the best quality and uniformity, combined with chemical binders and plasticizers. THERMOLITH is chemically neutral which accounts for its excellent resistance to corrosive slags and fumes of a wide range in chemical compositions.

ANKORITE 65 is a heat-setting high-alumina bonding mortar shipped in dry form. It is used to advantage under certain conditions for laying high-duty and superduty fireclay brick and high-alumina brick.

KORUNDAL BONDING MORTAR has extremely high refractoriness imparted by its alumina content of more than 85%. Its fusion point is in excess of 3300°F. and it is designed primarily for use with KORUNDAL brick and where extremely high refractoriness is required. It is an air-setting high temperature cement in the dry form.

CORALITE BONDING MORTAR is a strong air-setting high temperature cement with a high-alumina base. This material develops an extremely strong bond upon air-setting and is designed for use at very high temperatures. CORALITE BONDING MORTAR is shipped in the wet form in steel drums.

SPECIAL PURPOSE MORTARS. In addition to these high temperature mortars, Harbison-Walker produces others of a wide range in composition and physical properties. H-W CORUNDUM consists largely of crystalline alumina; FIREBOND is highly siliceous; H-W PERIKLASE is highly basic, consisting essentially of crystalline magnesia; and H-W FORSTERITE is the magnesium silicate mortar possessing unusual properties. These mortars are particularly adapted for specific applications.

HARWACO MASTIC is a plastic air-setting monolithic refractory which has a working consistency similar to that of stiff putty. It is ideally suited for plastering with a trowel, as for example, for sealing the V-shaped spaces at the exterior face of tangential tubes.

Others of major importance for their special purposes are Harbide Mortar (silicon carbide) and H-W Zircon mortar.

INSULATING REFRACTORIES

The savings afforded by the use of insulating firebrick in hot face and back-up applications—how its low thermal conductivity reduces warm-up time and fuel cost—how the low conductivity plus light weight permits thinner walls and roofs, and lighter furnace design is well known.

Today's interest is in finding the best insulating firebrick for the widest variety of applications. To meet this demand, Harbison-Walker offers the H-W LI (low iron) line.

Brand Name	H-W 20 LI	H-W 23 LI	H-W 26 LI	H-W 28 LI	H-W 30 LI	H-W 33 LI
Maximum Service Temperature	2000°F.	2300°F.	2600°F.	2800°F.	3000°F.	3300°F.
Selection of Brand	Any application of these insulating firebrick requires very careful consideration of furnace operating temperatures in relation to the maximum temperature limits given in this table. When insulating firebrick are used as backing for refractory firebrick, the maximum operating interface temperature that can prevail between the refractory lining and the insulation governs the choice.					

HARBISON-WALKER REFRACTORIES COMPANY and subsidiaries

General Offices: Pittsburgh 22, Pa.

World's Most Complete Refractories Service

SALES OFFICES

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Montreal, Que.
Toronto, Ont.

Litho in U. S. A.

Agents and Dealers throughout United States, Canada and other countries.

HW 61-A8

What's Happening

Continued from Page 45

fleet by 108 vessels, representing 90 percent of its present total tonnage, and plans further substantial expansion by 1965.

Russia today has only 2 percent of carrying capacity of world tanker fleet. It is, however, expecting to purchase from Free World large number of tankers in coming years and continue to charter tankers wherever possible so that Soviet oil can be moved to market.

Pooling petrochemicals

From Middle East comes proposal that all Arab states center attention toward launching joint petrochemical industries. Lebanon, leading campaign, stressed need for Arab oil-producing states to start pooling their petrochemical businesses. Proposal was made at Arab Oil Congress in Alexandria, Egypt.

Drawbacks of individual units: Prospects for individual units are meager, prevalent economic conditions generally poor, little demand prospect, lack of technical and marketing knowledge, and even availability of capital. Lebanon's delegation, which pointed out these facts, suggested that Arabs get together in joint coordinated effort to produce, consume regionally and export petrochemicals.

Exports up, prices down

Look for continued growth in Soviet Union oil exports to Western Europe and several other overseas countries. Increase will occur even at cost of further price concessions. Russia's increased volume of exports is due mainly to low price offers—ones that Western Hemisphere nations and Middle East countries cannot compete with.

Italy is good example: Its imports of crude from Soviet Union increased 50 percent in value and nearly 80 percent in volume, from 2.2 million tons in 1959, to 3.9 million tons in 1960. Italian refiners would rather pay one third less for Russian crude than buy imports from Iraq, Saudi Arabia and Kuwait.

Outlook: Italian trade agreement with U.S.S.R. foresees continued growth in Russian oil imports over next few years. Other nations increasing Russian crude imports are: Finland, Sweden and Greece.

GOVERNMENT

Higher fee for patents

U.S. Patent Office has its eye on higher fees for filing patents submitted by corporations and government, plus graduated charges during life of patent. Goal: To make patents pay for 75 percent of Patent Office operation costs. The Bill (H.R. 7731) would up current schedule of filing fees and require additional $100 charge at end of fifth year, $300 at end of ninth, and $500 at end of thirteenth. Charges would be accrued from day patent. Goal: To make patents pay for fees was not paid, patent would lapse. Individual inventors who still own patent could have fees deferred.

Eyes on anti-trust

Shoe and paper industries would seem to have little importance to HPI, but such is not case when it comes to legal skirmishes with Justice Department over anti-trust. Two cases before U.S. Supreme court involving St. Regis Paper and Brown Shoe will be watched closely by oil and chemical companies for hint of what may be ahead in way of JD moves against HPI mergers and joint enterprises.

In St. Regis Paper vs. U.S., court will decide whether FTC can make companies submit copies of confidential reports it prepares for Bureau of Census. In Brown Shoe case, court will rule on important question of what constitutes Clayton Act's reference to "substantial lessening of competition" in case of mergers. A 1950 amendment to Act outlaws any merger that substantially lessens competition in general, not simply competition between two companies merging. Widely publicized DuPont-General Motors case was decided on basis of Act as it stood before 1950 amendment.

High taxes = low sales

Leading tax administrators from over U.S. have been warned by oil industry representative that time has come to halt further gasoline tax increases.

R. H. Venn, vice president of

SKINNER-SEAL

PIPE JOINT CLAMP STOPS LEAKS

at joint where pipe is screwed into fitting

SKINNER-SEAL

PIPE JOINT CLAMP stops leaks at joints where pipe is screwed into fitting. Any temperature—any pressure up to 2,000 pounds. Saves the cost of tearing out and renewing leaky fittings. Prevents shutdowns. In stock at most oil supply stores.

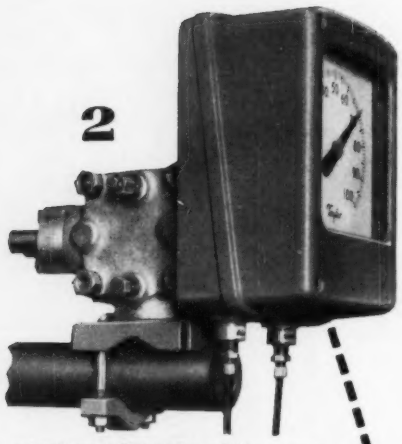
SKINNER-SEAL

EMERGENCY PIPE CLAMPS for safe, sure, lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12" for steel and C.I. pipe. Stocked by practically all oil supply stores.

Complete line of Repair Clamps. Send for Catalog 54!

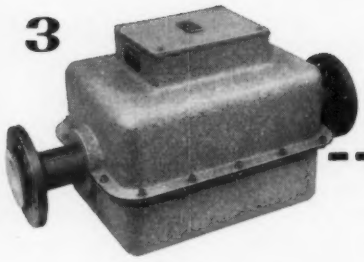
M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

For more data on advertised products, use cards, last page.



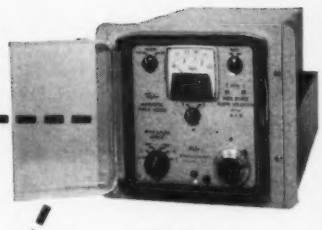
2

212T TRANSCOPE Differential
Pressure Transmitter

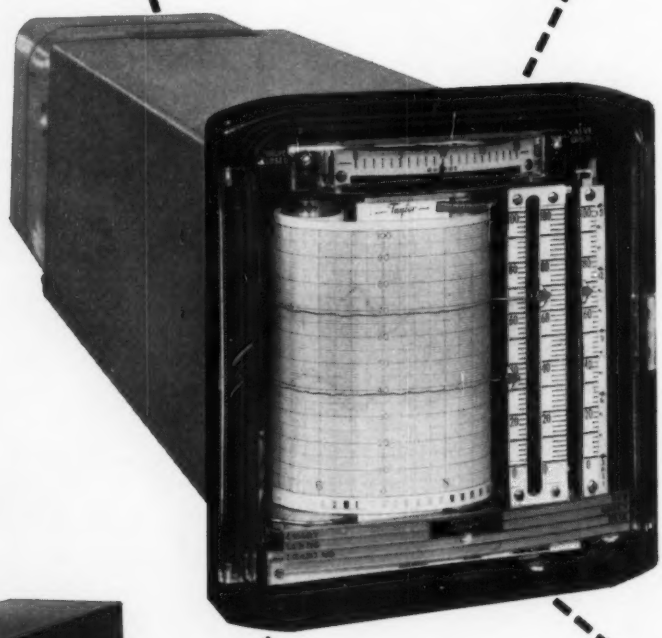


3

712NE
"MAG-PIPE" Sensing Head



717TE
"MAG-PIPE" Transmitter



1

TRANSCOPE Recorder
90J Pneumatic
700J Electronic

4

720T Solid State
Potentiometer

5

210 TRANSCOPE Motion-Balance
Pneumatic Transmitter

Taylor Instruments

SEE *Taylor*

ACCURACY IN ACTION

AT THE CHEMICAL SHOW

New Transmitters designed to take advantage of the superiorities of TRANSCOPE® RECORDERS

1 TRANSCOPE Recorders. 90J (pneumatic) and 700J (electronic) are the most convenient, most compact instruments yet developed for modern instrument panels. Powerful Servomatic motors give unprecedented recording accuracy, (½ of 1% standard; ¼ of 1% optional) also permit use of auxiliary functions such as integral alarms, retransmitting potentiometers, function generation and digital encoding etc. Front-of-panel control settings permit easy adjustment while recording. Write for **Bulletin 98286** (pneumatic) or **98335** (electronic).

2 212T TRANSCOPE Differential Pressure Transmitter. First and foremost a superior DP transmitter. Also the only DP Transmitter that can be calibrated for output *linear* with flow as well as differential pressure without changing parts. Servo power permits ratio and cascade control without intermediate, separate square root extraction. Simple analog computations involving flow and other variables handled pneumatically without a separate black box. Indicating and "blind" models. Write for **Bulletin 98413.**

3 MAG-PIPE* Magnetic Flowmeter Transmitter. Output signal of 1-5 ma gives high accuracy (½ of 1%) up to 10,000 feet, making centralized control rooms practical. Measures flow of liquids with electrical conductivity as low as distilled water. Ideally suited for very low flows, viscous liquids, and liquids containing suspended solids. Sensing head mounts in flow line—available with lap joint (Van Stone type) or sanitary type pipe connections. Transmitter is solid state for long reliability. Write for **Bulletin 98418.**

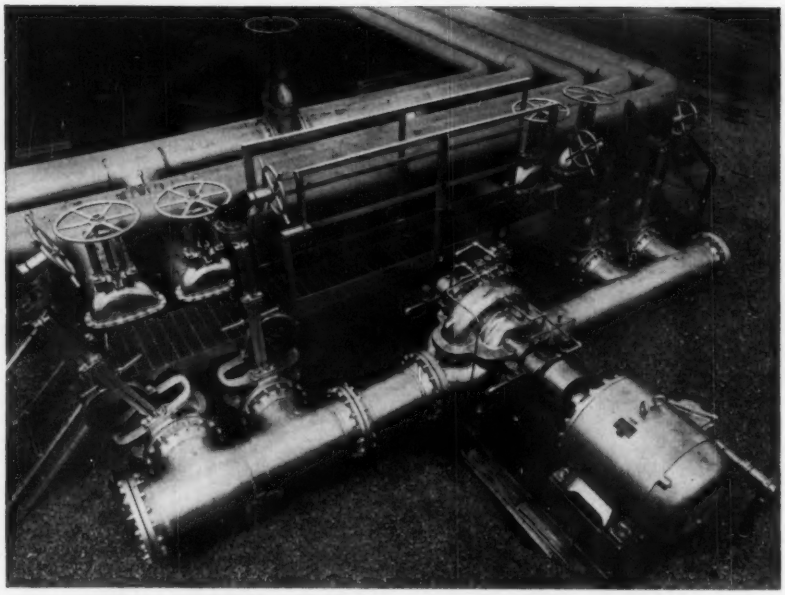
*Trade-Mark

4 720T Solid State Potentiometer Transmitter handles millivolt inputs and thermocouple inputs and provides a milliampere output. Fully transistorized including chopper; continuous vernier adjustment for span and zero; high calibrated accuracy (± .25% above 10Mv, ± .5% below 10 Mv.); multiple outputs—3 to 15 psi., 1 to 5 Ma DC; Output load 3000 ohms max. Full scale in 1.2 seconds. **Bulletin 98388**

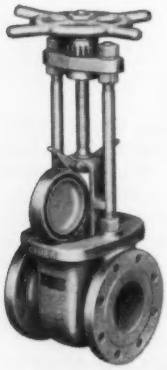
5 210T TRANSCOPE Motion-Balance Pneumatic Transmitter for gage pressure, volumetric pressure, volumetric load, and temperature transmission. Accuracy of transmitted signal is within ½% of input. Indication is ± 1% of actual value. Threshold sensitivity of 0.1% of input span. Big scale easily readable up to 35 ft. away. Only three basic parts for easy maintenance. Write for **Bulletin 98385.**

All of these instruments will be demonstrated along with many others in the Taylor **Booth 104** *at the Chemical Exposition. Be sure to stop in and see them. If you aren't attending the show ask your Taylor Field Engineer for a demonstration or write for Bulletins. Taylor Instrument Companies, Rochester, New York, and Toronto, Ontario.*

MEAN ACCURACY FIRST



NO SPILLAGE...NO LINE SPREADING with Hamer VISIBLE WEDGE LINE BLIND VALVE



Visible Wedge Line Blind Valves are available in three types:
STRAIGHTWAY
ASA 150 lbs. Sizes 1½" thru 18"
ASA 300 lbs. Sizes 1½" thru 16"
VERTICAL ELBOW and TEE
ASA 150 lbs. Sizes 3" thru 12"
ASA 300 lbs. Sizes 4" thru 12"

Where line spillage is intolerable or hazardous . . . where there is no space for line spreading, the HAMER Visible Wedge Line Blind Valve is the perfect installation.

Wedge type spectacle plates, pivoted on a yoke assembly and raised and lowered by a handwheel, seat and seal against stainless steel seats in the rigid body. The valve is opened or closed by raising the yoke assembly and switching the wedges. One wedge is always visible above the body to indicate from a distance whether valve is opened or closed.

Opening or blinding a line with the Visible Wedge Line Blind Valve is a one man operation requiring just a few minutes. Cost records from scores of users show you save 90% and more every time a line is blinded. Compare that with the cost of outmoded methods of line blinding and you can see why it pays to use Hamer Line Blind Valves.

Write for Hamer Catalog 60 for complete description of all types, sizes and pressure ratings.

HV-7-61

WECO®

WELL EQUIPMENT MFG. CORP.
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fmc CORPORATION

Division of CHIKSAN COMPANY
a subsidiary of FMC CORPORATION

Happenings . . .

Humble Oil & Refining Co.'s southeast region, said in speech before North American Gasoline Tax Conference in Mobile, Ala., that high gasoline taxes may be approaching point where they produce less than maximum potential for government treasuries.

"Motorist already has shown what he thinks about high gasoline taxes—he's buying less gasoline." Venn exclaimed, "How much heavier can the motorist's tax burden get before he decides to go on 'tax strike' by further reducing his consumption?"

Venn said after 1951 tax increase 27 states and District of Columbia suffered slowdown in rate of growth in gasoline consumption. Increase in 1956 was followed by lower growth rate in subsequent year in 40 states and 1959 tax increase was followed by similar adverse reaction next year in 39 states."

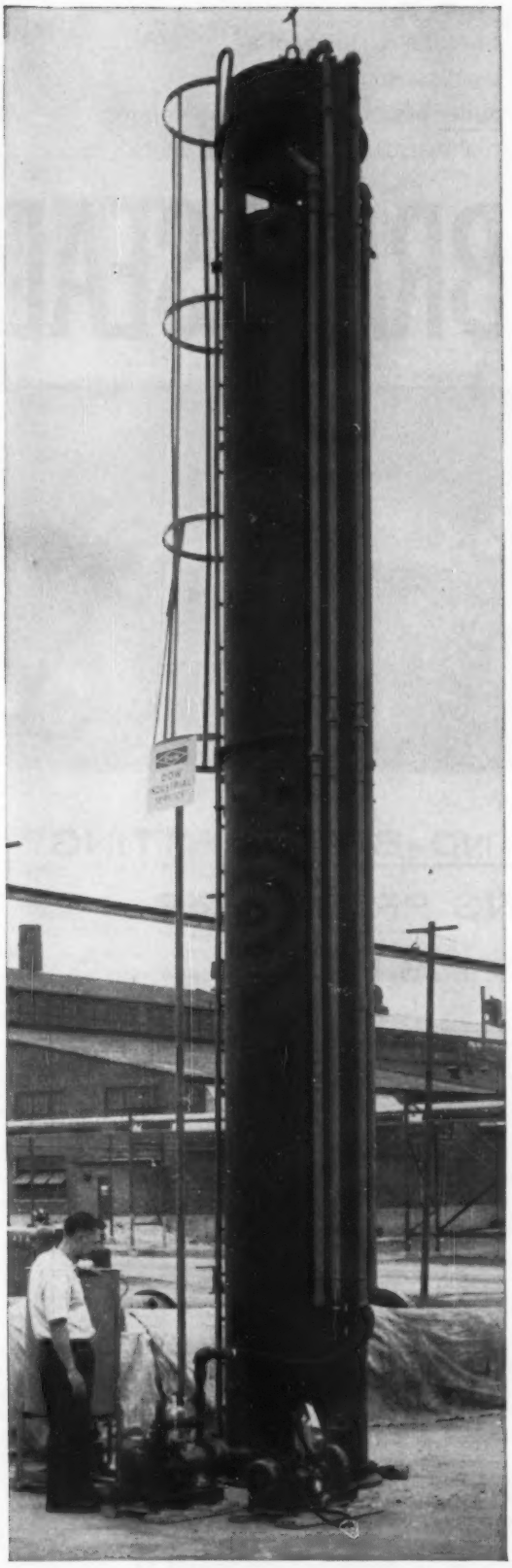
- Changing Times -

Texas City Refining is getting back in saddle again after Hurricane Carla damage. Almost month of continuous cleanup and repairing was necessary before first topping unit could be placed in operation. Other units are fast being put on stream.

Throughput reduction reports come from Phillips Petroleum Co. as firm reaches 14,000 bpd under August runs. While Phillips' refinery runs have been less during this period of 1961, its finished product sales are keeping pace with industry gain over 1960.

Reduced refinery runs amount to 7,500 bpd for DX Sunray Oil Co. at its two Oklahoma plants. Throughput reduction is for company's Duncan and Tulsa refineries. S. D. Breitweiser, company president, reports wholesale gasoline prices are at 9-year low at Oklahoma refineries.

For the fifth time during the past six years, the natural rubber industry is slated to sell more than it will produce in 1961. According to figures from Management Committee, International Rubber Study Group, rubber growers this year will produce some 2,035,000 tons; sell about 2,037,000.



Pilot plants are 28' high, 3' in diameter. They come completely assembled, with nutrient feeder, pumps and other equipment ready for connection and immediate use.

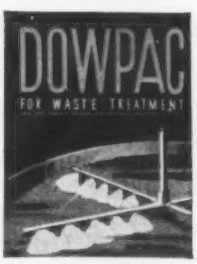
LOW-COST PILOT PLANT USING NEW DOW DEVELOPMENT CAN HELP SOLVE YOUR WASTE TREATMENT PROBLEMS!

Now, at little cost, you can install a trickling filter pilot plant using new Dowpac® biological oxidation media. This research tool will show you precisely how you can treat wastes efficiently . . . and how best to do it . . . under *your actual operating conditions.* Data obtained from pilot plants can be used for later scaling-up to full size—but compact—installations.

D.I.S. will lease or sell pilot plants, as you wish. D.I.S. engineers will assist in installing the plant, put it in operation for you, and interpret collected data to work out the most effective treatment for your particular problem.

Dowpac provides conditions approaching the design ideal for trickling filter-type systems, including light weight, to permit land-saving vertical construction . . . tremendous surface area for maximum bacteria growth . . . minimum of plugging or channeling . . . and practically no maintenance.

Write for new booklet on Dowpac, and for information on low-cost pilot plants. D.I.S. engineers will be glad to work with you to develop the most effective method for water and waste treatment for your particular conditions. Write DOW INDUSTRIAL SERVICE, 20575 Center Ridge Road, Cleveland 16, Ohio, Dept. HP&PR11.



Dowpac is a trademark for packing media—not pilot plants.

DOW

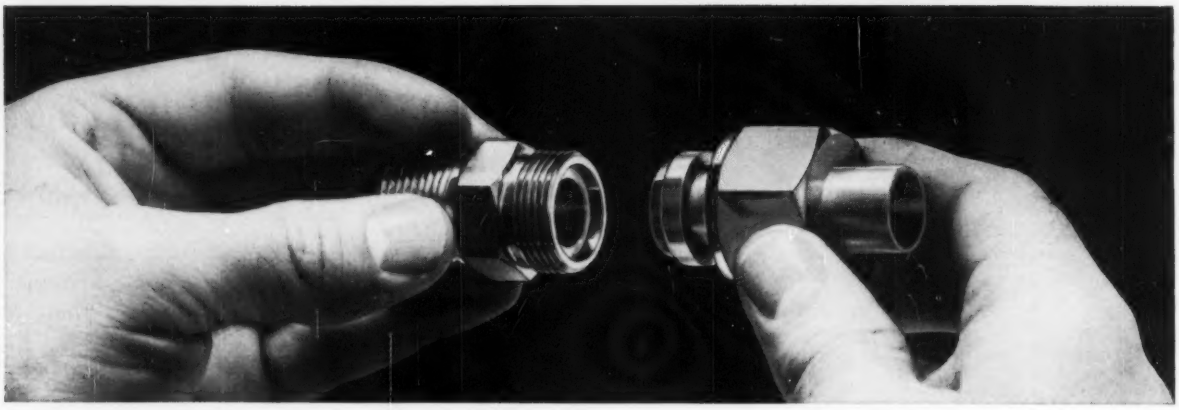
DOW INDUSTRIAL SERVICE

Division of The Dow Chemical Company

PROBLEM: absolute reliability of a weldless tube fitting under super pressures, high temperatures, high-frequency vibration or shock

SOLUTION:

BRAZE-SEAL



THIS BUTT-JOINT, MAKE-AND-BREAK FITTING WITHSTANDS WORKING PRESSURES UP TO 19,000 P.S.I.*

On many installations where you think only a more costly welded tube fitting can do the job, this Imperial butt-joint BRAZE-SEAL fitting now takes over. It's a compact, economical, simple-to-install fitting withstanding *super* working pressures (see table). It won't yield to high-frequency vibration or shock. With special brazing alloy rings, this fitting withstands temperatures up to 1500° F.

Because Braze-Seal fittings are not welded, you retain the convenience of a make-and-break joint. For more details, call your nearby Imperial-Eastman distributor—or write for Bulletin 3120.

MAXIMUM DESIGN PRESSURES FOR BRAZE-SEAL FITTINGS		
Tube O.D.	P.S.I.—316 Stainless	P.S.I.—Carbon Steel
¼"	77,000	60,000
⅜"	64,000	48,000
½"	62,400	46,800
9/16"	61,600	—
⅝"	61,600	46,200
¾"	60,000	45,000
⅞"	56,000	42,000
1"	52,000	39,000
1¼"	48,000	36,000
1½"	44,000	33,000

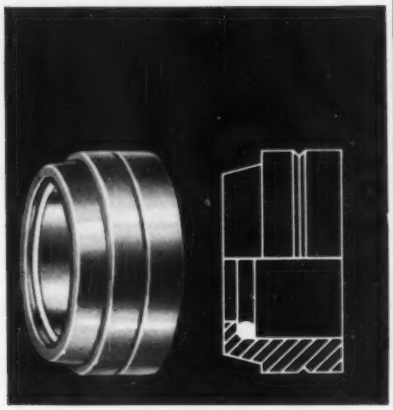
*Recommended working pressures allow for 4-to-1 safety factor on sizes up to ¾" O.D.; 6-to-1 on sizes ¾" to 1½" O.D.

IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario • Imperial-Eastman, S.A., Apartado Postal 26544, Mexico 13, D.F.

FITTINGS



secret of superiority—
silver alloy brazing ring

Inside the Braze-Seal fitting sleeve is a brazing ring of silver alloy. When the sleeve is slipped over the tube end and heated, the alloy forms a tough, lasting bond between the tube and sleeve. After brazing, the fitting is easily assembled —no special machining necessary, no special tubing required, no flaring, no danger of "over-torquing" the fitting because you can see when it's tight.

Braze-Seal fittings offer other Hi-Seal fitting advantages: make-and-break convenience, close bends made possible, and economy of installation.

6-FLAME TORCH SPEEDS BRAZING
This Braze-Seal acetylene torch simplifies the making of brazed joints. Six-flame jet on circular tip heats sleeve evenly—quickly brazes the silver alloy to form a super-pressure-tight seal.

IMPERIAL — EASTMAN

Meetings Calendar

November

13-15.....**American Petroleum Institute,** Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

-17.....**Natural Gas Processors Association,** Panhandle Plains Regional Meeting,
26- Herring Hotel, Amarillo, Texas.

Dec. 1.....**American Society of Mechanical Engineers,** Winter Annual Meeting,
27- Statler Hilton Hotel, New York, N. Y.

Dec. 1.....**Exposition of Chemical Industries,** New York Coliseum, New York, N. Y.
27-

Dec. 1.....**National Association of Corrosion Engineers,** Southeast Regional Conference, Miami, Fla.

December

3- 6.....**American Institute of Chemical Engineers,** Annual Meeting, Hotel Commodore, New York, N.Y.

3- 7.....**Eastern Joint Computer Conference,** Sheraton-Park Hotel, Washington, D.C.

5- 6.....**National Petroleum Refiners Association,** Computer Conference for Refiners, Hotel Tulsa, Tulsa, Okla.

7- 9.....**American Chemical Society,** Southeast and Southwest Regional Meetings, New Orleans, La.

28-29.....**ACS,** Division of Industrial and Engineering Chemistry, Christmas Symposium, University of Delaware, Newark, Del.

1962

January

8-12.....**Society of Automotive Engineers,** Annual Meeting, Cobo Hall, Detroit, Mich.

17-19.....**NACE,** Canadian Region Eastern Division Conference, King Edward Hotel, Toronto, Ont.

-19....****NGPA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.

22-25.....**National Plant Engineering & Maintenance Show,** Convention Hall,
31- Philadelphia, Pa.

Feb. 1....***NPRA,** Gulf Coast Regional Meeting, Ben Milam Hotel, Houston, Texas. Texas.

February

4- 7.....**AIChE,** National Meeting, Statler Hotel, Los Angeles, Calif.

-16....****NGPA,** South Louisiana Regional Meeting, Lafayette Petroleum Club, Lafayette, La.

March

4- 8.....**ASME,** Gas Turbine-Process Industries Conference, Shamrock Hilton Hotel, Houston, Texas

6- 7.....***NPRA,** Eastern Regional Meeting, Sheraton-Cleveland Hotel, Cleveland, Ohio.

-16....****NGPA,** Oklahoma Regional Meeting, Sheraton-Oklahoma Hotel, Oklahoma City, Okla.

18-22.....**NACE,** Meeting, Municipal Auditorium, Kansas City, Mo.

20-29.....**ACS,** National Meeting, Washington, D. C.

April

2- 4.....***NPRA,** Annual Meeting, Granada Hotel, San Antonio, Texas.

9-10.....**Instrument Society of America,** National Chemical & Petroleum Instrumentation Symposium, Wilmington, Del.

15-18.....**ASME,** Oil and Gas Power Division Conference, Shoreham Hotel, Washington, D.C.

17-19.....**American Society for Metals,** Regional Conference and Exhibiton: Materials and Materials Processing for Petroleum, Petrochemical and Chemical Industries, Shamrock Hilton Hotel, Houston, Texas.

***NPRA—National Petroleum Refiners Association.**
****NGPA—Natural Gas Processors Association.**

Men in HPI...

Gordon

J. A. Gordon, an engineer with Union Oil Co. of California, has received the California Natural Gasoline Association Annual Award. The award, according to a CNGA booklet, "emphasizes to younger members that their services to the association, manifested not only by purely technical pursuits but also in a variety of other ways, is appreciated by CNGA." Gordon, who is with Union Oil's Natural Gas and Gasoline Department, was chairman of the CNGA fall meeting committee in 1960.

Jerome J. O'Brien has been appointed director of the Office of Oil & Gas, U.S. Department of the Interior. O'Brien, formerly president of Texas Independent Producers & Royalty Owners Association, has been vice president, Monterey Division, mid-continent region, Humble Oil & Refining Co.

William B. Hudson has been named executive vice president in charge of the Petroleum and Chemicals Division, Arthur G. McKee & Co. Hudson was formerly vice president of refinery engineering. He will be a member of an executive committee set up to direct operations of Arthur G. McKee.

Milburn S. Weir has been appointed superintendent of operations, Oxo Chemicals Co.'s plant presently under construction at Haverhill, Ohio. **W. D. Baskin,** maintenance supervisor at the firm's Joliet, Ill., aromatics acids plant, has been promoted to superintendent of maintenance and engineering at Haverhill. **Murl Lucas** has become administrative supervisor.

Eugene Houdry is winner of the 1962 ACS Award in Industrial and Engineering Chemistry, sponsored by Esso Research and Engineering Co. Houdry, founder of Houdry Process Corp., is the inventor of the first successful catalytic cracking process for the oil industry. The award, which consists of a gold medal and $1,000, will be presented at the 1962 national ACS meeting.

Dan M. Krausse, senior vice president of Cosden Petroleum Corp., will leave the corporation this month to join Dresser Industries, Inc., Dallas, as vice president. **R. L. Tollett,** Cosden's president and general manager, will assume Krausse's managerial responsibilities in the Refining & Chemical Division. Since September 1957, Krausse has been a senior vice president of Cosden and headed its Refining & Chemical Division.

Krausse

Paul L. Fahrney and Elmer R. Peterson have been elected to the board of directors, Standard Oil Co. of California. Fahrney joined Standard-California in 1920 as an asphalt research chemist. Peterson has been with the company since 1923 specializing in financial analysis.

C. R. Summers, Jr., has been appointed director, product quality coordination, Refining Department, Gulf Oil Corp.'s headquarters in Pittsburgh. He succeeds the late **A. S. Orr.** Summers had been technical associate, Gulf Research & Development Co. laboratory at Harmarville, Pa.

Norman Hardy has retired as chairman of the board of directors, Arabian American Oil Co. President **Thomas C. Barger** will become chief executive officer. **R. I. Brougham**

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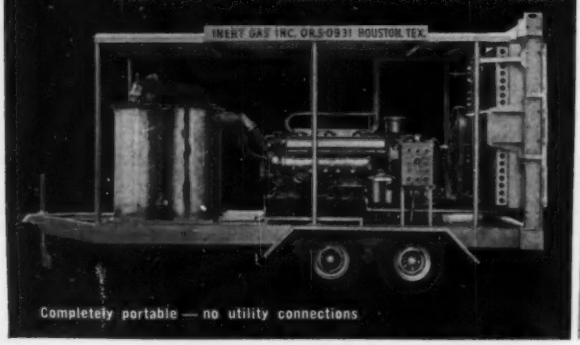

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GARLOCK

Men . . .

and **Paul H. Arnot** have been named senior vice presidents.

Cecil Chilton has been elected president, American Association of Cost Engineers, for 1962. Chilton is editor in chief of Chemical Engineering magazine. Other association officers for 1962 are: Vice president, **Donald I. Meikle,** Meissner Engineers, Inc.; treasurer, **Wesley J. Dodge,** Socony Mobil Oil Co.; and secretary, **Thomas C. Ponder,** petrochemicals editor, HYDROCARBON PROCESSING & PETROLEUM REFINER.

Matthew V. Carson, Jr., from April 1958 to April 1961 director of the Office of Oil & Gas, Department of the Interior, has been elected a vice president, Sinclair Refining Co. Carson, who also was the first administrator of the mandatory oil import program, is being assigned to the Washington office of Sinclair Refining as company representative. He replaces **Orville D. Judd.** Carson joined Sinclair in May 1961.

Carson

Frank N. Ikard of Wichita Falls, Texas, has been elected executive vice president, American Petroleum Institute. Ikard has been a U.S. representative of the 13th Congressional district of Texas since 1951.

Dr. Giulio Natta, director of the Institute of Industrial Chemistry, Polytechnic Institute of Milan, has been awarded the first International Gold Medal of the synthetic rubber industry. The award will be given annually for outstanding achievement in, and contribution to, synthetic rubber chemistry.

Homer E. Henslee has been appointed manager, Process Plants Division, Foster Wheeler (Canada), Ltd. Henslee was in project management handling mechanical design and construction of all types of refinery units. Before joining Foster Wheeler in 1942, he was with Magnolia Petroleum & Sinclair-Prairie Oil Co. on natural

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Accurate and automatic measurement of viscosity on process streams can significantly speed many refining operations, improve product quality and conserve blending materials. The PSD CONTINUOUS VISCOSIMETER* is accurate to 0.5% of scale over the viscosity range of 30—2500 SSU and temperatures from 100-210° F. For more viscous materials, such as asphalt, extended ranges of viscosity and temperature can be supplied.

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2. *Helps Get Higher Yields* . . . For crude-running units the CONTINUOUS VISCOSIMETER provides more accurate control of distillate quality, reduces diversion of distillates to gas oil, increases utilization of crude for valuable products. For deasphalting and dewaxing processes, the instrument helps segregate products accurately—prevents degrading the value of end products. For packaging operations, continuous viscosity monitoring prevents the loss of final product due to contamination.

3. *Increases the Value of Low-Grade Stock* . . . In the blending of residual fuels the CONTINUOUS VISCOSIMETER helps you capitalize on maximum use of less-costly cycle stocks.

4. *Helps Make Better Quality Products* . . . For blending operations the PSD CONTINUOUS VISCOSIMETER maintains products consistently within specifications. Continuous viscosity measurements of laboratory accuracy reliably aid operators to eliminate peak and valley variations in quality.

5. *Reduces Indirect Costs* . . . In all refining operations the PSD CONTINUOUS VISCOSIMETER considerably reduces the need for reprocessing—through more accurate control at each refining step. It reduces the amount of storage capacity required. It speeds the release of product shipment through "on-the-spot" monitoring of product quality.

HOW IT WORKS . . . Sample is furnished continuously from the process line or vessel to the CONTINUOUS VISCOSIMETER, where it is brought to test temperature by flowing through a heat exchanger immersed in the constant temperature bath. Sample then passes through a pressure regulator to a constant-rate metering device that is also immersed in the bath. Under these conditions of constant volumetric rate and temperature, the pressure exerted by the sample at the entrance to the measuring capillary is proportional to the viscosity of the liquid. This pressure is sensed by a strain gauge having an accuracy of ±0.25%. The signal from the strain gauge is recorded in convenient viscosity units, either Saybolt Seconds or centistokes, as specified.

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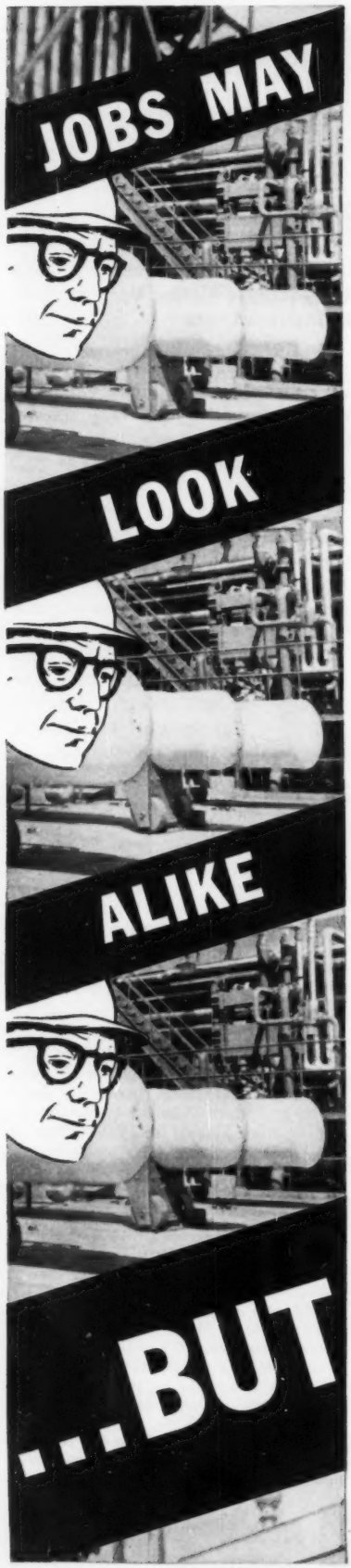

Men . . .

gasoline plant design and construction; and with Ford, Bacon and Davis on chemical plant construction and operation.

S. A. Ballard has been named research and development manager, Industrial Chemicals Division, Shell Chemical Co. Ballard joined Shell in 1937 as a research chemist for Shell Development Co., Emeryville, Calif.

Robert Schaffer has joined the Whiting, Ind., research laboratories, American Oil Co. He will carry out research on instrumental methods of chemical analysis.

Dr. John R. Lovett has been promoted to a section head by Esso Research and Enginering Co. Dr. Lovett is with the company's special project concerned with developing new and improved solid rocket fuels.

Louis E. Green has been appointed senior research scientist, American Oil Co., Whiting, Ind., research laboratories. **Emil M. Banas** and **Cecil G. Brannan** have been named senior project chemists. **James E. Pitrak** has been promoted to project engineer.

Raymond J. Pikna has been promoted to plant manager, The Firestone Tire & Rubber Co.'s new synthetic rubber plant, Port Jerome, France. Pikna was a research engineer and assistant project engineer for the construction of the synthetic rubber facility, Firestone Petrochemical Center, Orange, Texas. **Charles H. Hammond** has been appointed production manager at Port Jerome.

Fred Barlow has been appointed supervisor, United Carbon Service Laboratory, Akron, Ohio. Prior to joining United Carbon, Barlow was laboratory director at Thermatomic Carbon Co. for six years. He began his career in 1943 as development engineer with Dominion Rubber Co.

G. R. Preston of Bartlesville has been elected a vice president of Cities Service Petroleum Co. Preston joined Cities Service in 1925 after graduating from Oklahoma State University.

William S. James, head of William S. James Associates, Detroit, has been appointed automotive consultant, Houston Chemical Corp. James will serve as technical liaison with the automotive industry in matters relating to use of anti-knock additives such as tetraethyl and tetramethyl leads, as well as ethylene glycol and other automotive products.

James

Dr. Robert R. Dugan, Houston, has been promoted to medical director, Continental Oil Co. Formerly assistant medical director, he will continue to make his headquarters at Houston and will succeed **Dr. W. O. Armstrong,** Ponca City, Okla., who has retired.

John C. Quilty has been elected vice president of personnel and industrial relations, Shell Oil Co. He will succeed **E. H. Walker,** who will retire December 1. Quilty joined Shell in 1934.

Thomas A. Hendricks, contract engineer, Engineering Department, Monsanto Chemical Co.'s Inorganic Chemicals Division, has been appointed construction manager for the division.

Dr. Romulo Quintero has been made manager of manufacturing and a director of Mobil Oil Co. de Venezuela. Dr. Quintero has been with Mobil de Venezuela for six years. For the past seven months he has been manager of Mobil's 50,000 bpd refinery at El Palito on Venezuela's north coast.

Z. D. Bonner, formerly Far East manager, has been named manager, Crude Oil Department, Gulf Eastern Co. in London, England. He succeeds **F. R. Drury,** who has been transferred to Gulf's general office in Pittsburgh. Bonner joined Gulf in 1941 at its Port Arthur, Texas, refinery.

Dr. W. B. Franklin has been named chairman of the advisory council, Engineering Foundation at The University of Texas. The council is composed of industrial and business men who serve the College of Engineering

in helping plan programs and in securing financial aid to support the program.

Dr. John Forgrieve has been appointed to head a section in the General Engineering Division, Esso Research and Engineering Co. Dr. Forgrieve will be responsible for process equipment development work.

J. Gerald Ross has been elected to the administrative staff, The Ralph M. Parsons Co., Los Angeles. Ross was Project Division manager, C F Braun & Co.

Robert A. Dinerstein, section leader, Whiting, Ind., research laboratories, American Oil Co., has been named chairman of the advisory committee, research project on synthesis and purification of hydrocarbon standards sponsored by the American Petroleum Institute.

Paul J. Schauer has been appointed manufacturing superintendent, Monsanto Chemical Co.'s Inorganic Chemicals Division, St. Charles, Mo., plant, after serving as technical superintendent at that location.

Preston P. Nibley has joined the Engineering Department, Socony Mobil Oil Co., Inc., as an engineer consultant. He has been manager of operations in New York for Trans-Arabian Pipe Line Co.

Dr. Melvin Mooney, retired United States Rubber Co. scientist, will receive one of the rubber industry's highest honors, the annual Charles Goodyear Medal. The medal will be awarded by the American Chemical Society's Rubber Chemistry Division at its spring meeting in Boston, April 26, 1962.

N. M. L. Watson, acting area coordinator of Bataafse Internationale Petroleum Maatschappij for North Europe, has been elected vice president and a director of Asiatic Petroleum Corp. He will also be assistant to the president.

Vernon R. Dodd has been named production superintendent, Cities Service Petroleum Co.'s Guymon, Okla., gasoline plant. Dodd succeeds **C. E. Means,** who has retired. **W. R. Martin,** production superintendent of the May gasoline plant near Riviera,

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Men . . .

Texas, will succeed Dodd as maintenance superintendent at the Roberts Ranch gasoline plant near Odessa, Texas.

David W. Young, research associate for Sinclair Research, Inc., has been named recipient of the Chicago Technical Societies Council Merit Award. The award is made annually on the basis of civic and community contributions and scientific and technical achievements. Young was a nominee from the Chicago chapter, American Institute of Chemists, and Chicago chapter, American Chemical Society. He has patented a synthetic lubricant for turbo-jet aircraft engines and rockets.

Young

Roderic C. Lancey has been transferred from Monsanto Chemical Co.'s Organic Chemicals Division Development Department to the company's Overseas Division Development Department as a project manager.

Dr. Donald R. Diggs has been appointed assistant to the technical manager, E. I. du Pont de Nemours & Co.'s Petroleum Chemicals Division. Dr. Diggs, who has been with Du Pont for 11 years working in combustion research, will be primarily concerned with developments in automotive exhaust control.

Dr. John F. Horner has been named assistant manager of general engineering, Manufacturing Department, American Oil Co., in charge of process engineering. Dr. Horner has been with the company since 1949, when he started at the Texas City refinery in pilot plant work.

Charles L. Greiser, formerly with Irving Refining Co., Ltd., in Saint John, New Brunswick, Canada, has joined the Lockheed Missiles and Space Co. as test equipment engineer at its Sunnyvale, Calif., plant. He was foreman, Instrument Department, Irving Refining.

John G. McLean, financial vice president of Continental Oil Co., has been elected a director of Continental. McLean, who will continue to make his headquarters in New York City, has also become vice president for international and financial activities.

Hal W. Earhart has been promoted to research specialist, Humble Oil & Refining Co.'s Research and Development Department, Baytown, Texas. At present, he is on a rotational assignment as laboratory head at Humble's special products plant in Houston.

M. L. Mullins has been appointed assistant manager of safety, Central Employe Relations Department, American Oil Co. at Chicago. He succeeds **William F. Schreiber.** Mullins has been assistant supervisor of personnel development, Personnel Relations Division.

Gerard J. Forney has joined Bechtel Corp., San Francisco, as executive engineer, International Division. Ear-

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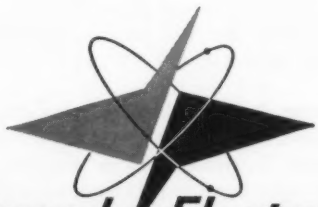

Diamond Electronics

Diamond Power Specialty Corporation • Lancaster, Ohio

lier this year, under the sponsorship of the International Cooperation Administration, Forney conducted a survey of Turkey's nitrogen fertilizer industry.

Clifford Wolf has been named production manager, Fiske Brothers Refining Co., Newark, N. J. **G. Edward Merkle, Jr.,** has been promoted to plant manager, and **Justin P. McCarthy** to plant superintendent for the company.

Arthur W. Lucas of New York, vice president of finance for The Chemstrand Corp., has been elected a vice president of Monsanto Chemical Co. Lucas will be headquartered at St. Louis and will serve as chairman of Monsanto's new corporate planning and evaluation staff.

Charles J. Randolph, Jr., has been appointed engineering manager, Chemical Division, United Engineers & Constructors, Inc., Philadelphia. Randolph was with Girdler Corp. for 18 years, most recently as manager of engineering and construction programs.

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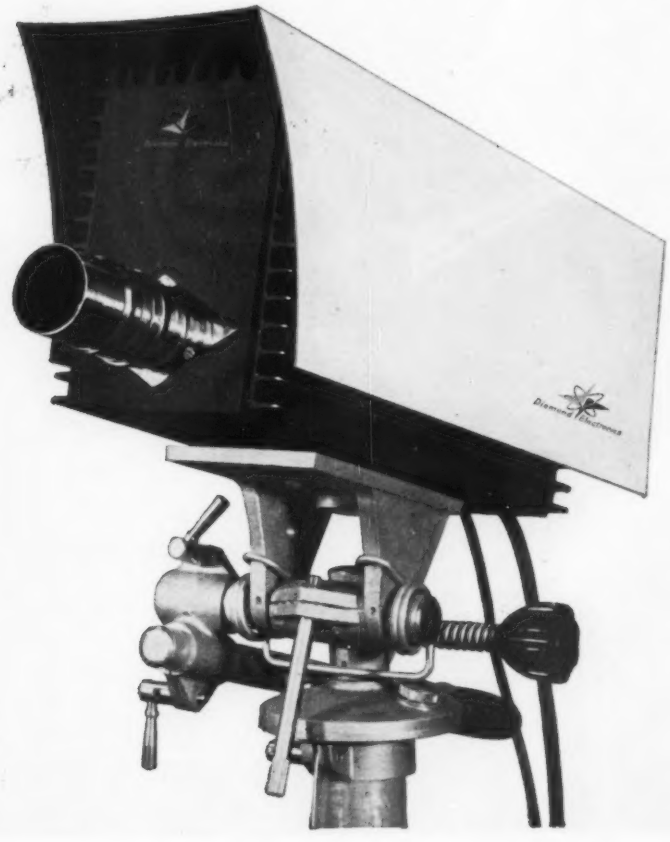


Robert N. Custer has been promoted to administrative assistant to the director of engineering, Sun Oil Co. Custer has been head of the planning and standards group, Engineering Division. He joined Sun Oil as a laboratory technician, Marcus Hook, Pa., refinery, in June 1940.

Edward T. Kubu has been named assistant director of laboratory research, Central Research Laboratory, Allied Chemical Corp., Morris Township, N.J. Kubu has been with Allied since September 1959.

Dr. Ralph P. Hudson has been appointed chief of the Heat Division, National Bureau of Standards, U. S. Department of Commerce. He succeeds **Dr. Charles M. Herzfeld,** recently appointed associate director of NBS.

Eger V. Murphree, president of Esso Research and Engineering Co., has been named to head the U.S. National Committee for the Sixth World Petroleum Congress, slated for June 1963 in Frankfurt, West Germany. **Jerry McAfee,** vice president, Gulf Oil Corp., and **Howard B. Nichols,** senior vice president, Caltex, have been appointed vice chairmen.

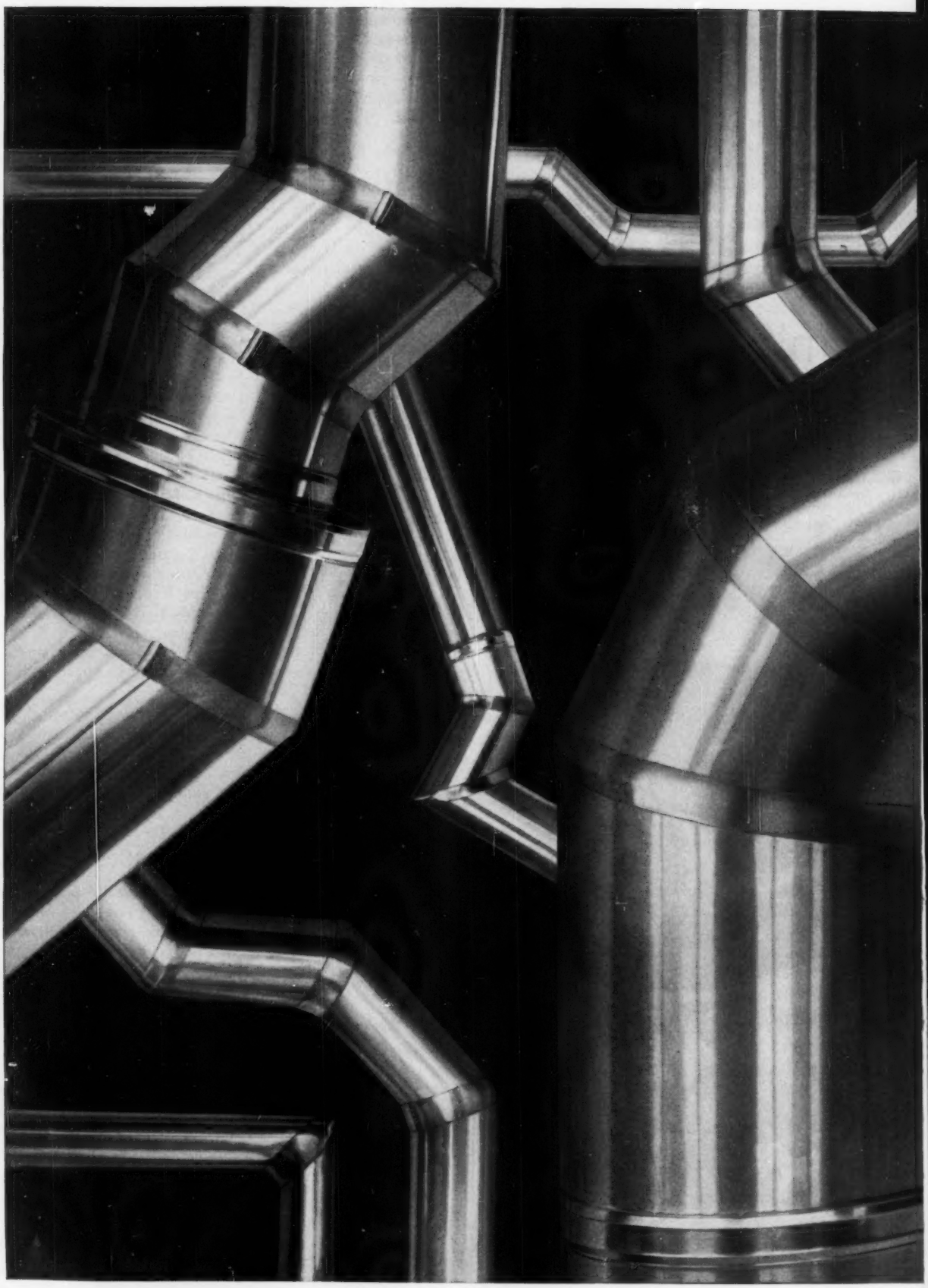
Earle B. Barnes, Freeport, Texas, has been appointed an assistant secretary, The Dow Chemical Co., succeeding **Luther Evans.** Barnes is general manager, Dow's Texas Division. Evans, formerly assistant general manager, Texas Division, is manager, Rocky Flats, Col., plant.

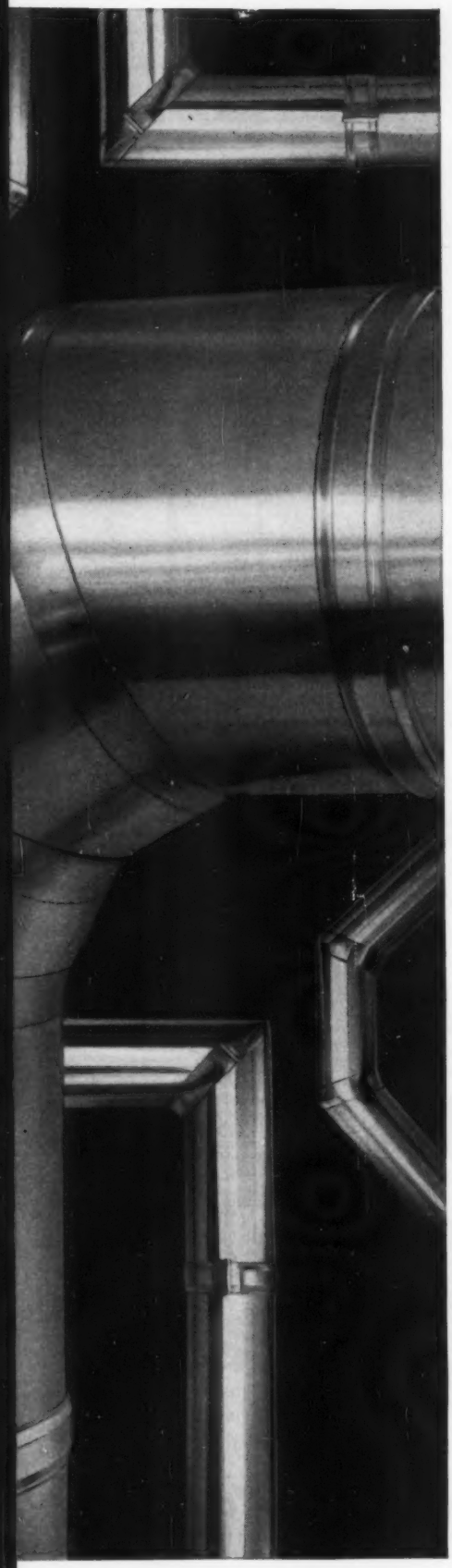
John R. Donnell has been named vice president in charge of all international activities, The Ohio Oil Co. He will coordinate refining, production, exploration, transportation and marketing over a ten-country area outside the United States. He will headquarter at Findlay, Ohio.

Eugene H. Hirschberg has joined the Whiting, Ind., research laboratories, American Oil Co. He will carry out fundamental research on the combustion reactions of gasoline.

H. W. Magee has been named petrochemicals representative for Gulf Oil Corp. and its subsidiary, Transocean Chemical Co., in Europe. Magee, who has been special representative for

For more data on advertised products, use cards, last page.





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J-M research has developed Miter-Seal®, a factory-made, preformed aluminum band. It has a clip at one end that can be tightened in a flash with a J-M Banding Wrench. *One* measurement, *one* cut, *one* application, and both insulation and jacket are applied. A quick turn of the Banding Wrench on the Miter-Seal completes the job! (See below.)

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Miter-Seal

J-M Banding Wrench

THE METHOD

Mitering section of Metal-On. Both jacket and Thermobestos are cut in one step with ordinary carpenter's saw.

Mitered section of Metal-On is placed on 90° fitting.

Miter-Seal sealing compound is placed in mitered joint.

Miter-Seal bands are applied and tightened to finish fitting.

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In service since 1959, these De Laval compressors demonstrate that multistage compressors are practical for chlorine compression. This service requires that the gas temperature must not exceed a nominal level throughout the compression cycle. The De Laval design meets this requirement through internal diaphragm cooling, circulating carbon tetrachloride. The cooling system has remained free from leaks . . . which testifies to the quality of both the design and the workmanship. This installation is typical of De Laval's ability to solve special compression problems for the Process Industries. Why not benefit from our many years of experience in this field?

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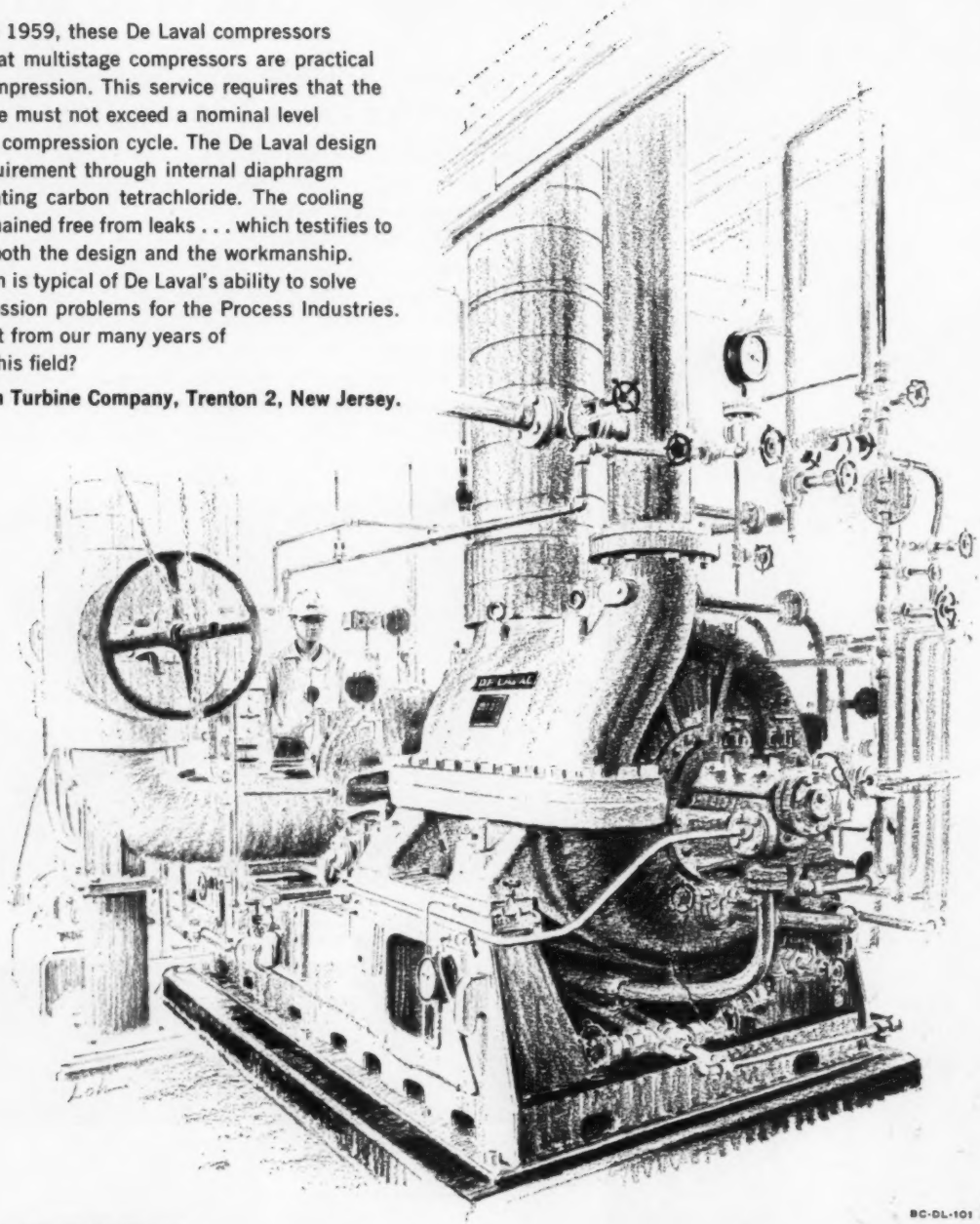

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Men . . .

Europe in Gulf Oil's Petrochemicals Department, will transfer from London to Milan, where he will be liaison man between Gulf companies and Soc. Italiana Resine-Gulf, which is building a phenol plant on Sardinia.

M. L. Haider, a vice president and director of Standard Oil Co. (New Jersey), has been elected an executive vice president and member of the executive committee. He will continue on Jersey Standard's board as contact director for the company's affiliates and activities in Latin America.

Dr. Neil V. Hakala has been named director of Esso Research & Engineering Co., Abingdon, England. Dr. Hakala, who has also been elected to Esso Research's board, was deputy to the vice president of petroleum products, medical, basic and analytical research. He replaces **C. S. Windebank,** who has become vice chairman of Jersey Standard's new uses activities in New York.

Robert O. Jennings has been elected vice president, Signal Oil and Gas Co. Jennings joined Signal in 1960 as general manager of crude oil purchases, sales and supply and transportation, and continues in that capacity.

William C. Ferguson has been promoted to senior research chemist, Union Oil Co. of California's Research Center, Brea, Calif.

Arnold Stebinger has been appointed international government relations advisor, Government Relations Department, Socony Mobil Oil Co. Stebinger joined the company in 1938 as a foreign trade trainee. Since March 1959, he has been regional vice president (Far East), Mobil International Oil Co.

Willis M. Cooper has been named director, Applied Mathematics Department, Monsanto Chemical Co. The department has recently been set up as a part of Monsanto's Research and Engineering Division.

Dr. Robert E. Malec has been named project chemist, Research and Development Department, American Oil

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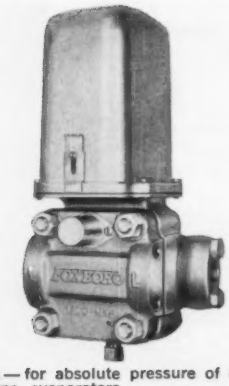
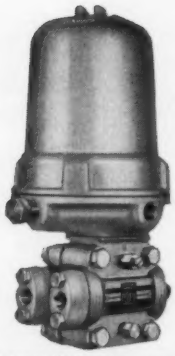
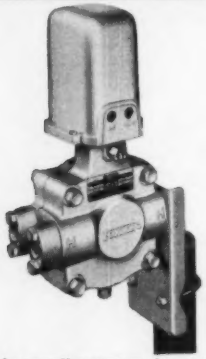


T13AA — for absolute pressure of dryers, columns, evaporators.

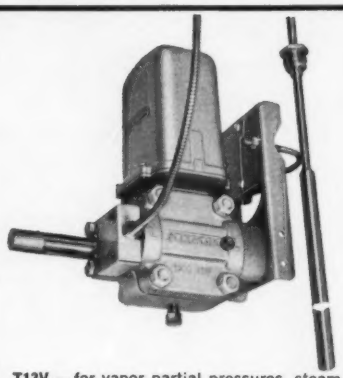


T613 — for long distance measurement of flow, level, pressure drop. All electronic transmission.

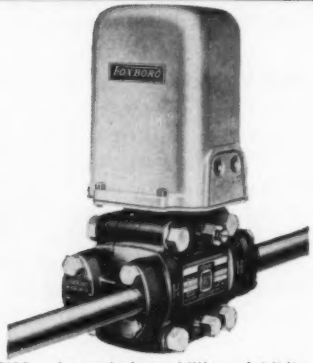
T13A — for metering practically all process flows, densities, liquid level.



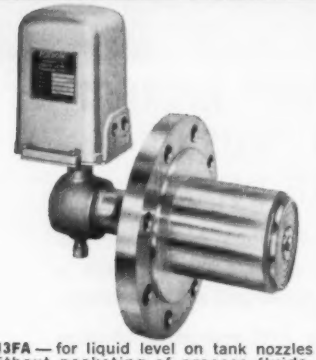
T15A — for small pressure drop across filters, heaters, orifices; for small liquid level heights, density measurement.



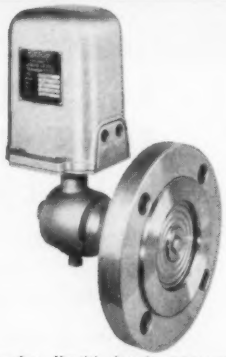
T13V — for vapor partial pressures, steam stripping or column control.



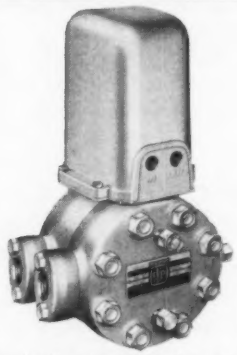
T13A — for metering additives, inhibitors, reactants, product gas or liquid — .003 to 10 gpm.



T13FA — for liquid level on tank nozzles without pocketing of process fluids: mounts flush with tank interior.



T13FA — for liquid level measurement: mounts direct on nozzle or tank flange.



T13HA — for flow, level, interfaces at pressures up to 6000 psi.

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Men . . .

Co., Whiting, Ind. Dr. Malec, who joined the company in 1957, has carried out extensive research in laboratory synthesis and evaluation of new compounds used to raise gasoline quality.

Dr. Warren Lee McCabe, administrative dean, Polytechnic Institute of Brooklyn, has been named acting head, Department of Chemical Engineering. He succeeds **Dr. Donald F. Othmer,** who requested to be relieved of his administrative duties after 24 years as department head. McCabe retains his post as administrative dean.

William A. Wildhack has been appointed an associate director, National Bureau of Standards. He will handle coordination of NBS measurement services including consultation and research on special problems of measurement, and calibrations and tests performed on instruments, equipment, etc.

James E. Chaffin of Bartlesville has been named safety director, Industrial Relations Division, Cities Service Petroleum Co. Chaffin is transferring to Cities Service Petroleum from its affiliate, Cities Service Pipe Line Co.

Edward T. Herndon, a senior partner of Eastman, Dillon, Union Securities & Co., has been elected a director, Mission Development Co. Mission Development controls Tidewater Oil Co. and is, in turn, controlled by Getty Oil Co.

R. E. Williams has been appointed senior research engineer, Richmond Laboratory, California Research Corp. Williams is presently assigned to the process planning section.

Richard J. Lee has joined the Whiting, Ind., research laboratories, American Oil Co. He will carry out laboratory investigations of new compounds to improve motor oils.

Dr. Thomas L. Gresham has been elected a vice president, Air Products and Chemicals, Inc., Allentown, Pa. Dr. Gresham was formerly vice president, research and development, A. E. Staley Manufacturing Co. He holds

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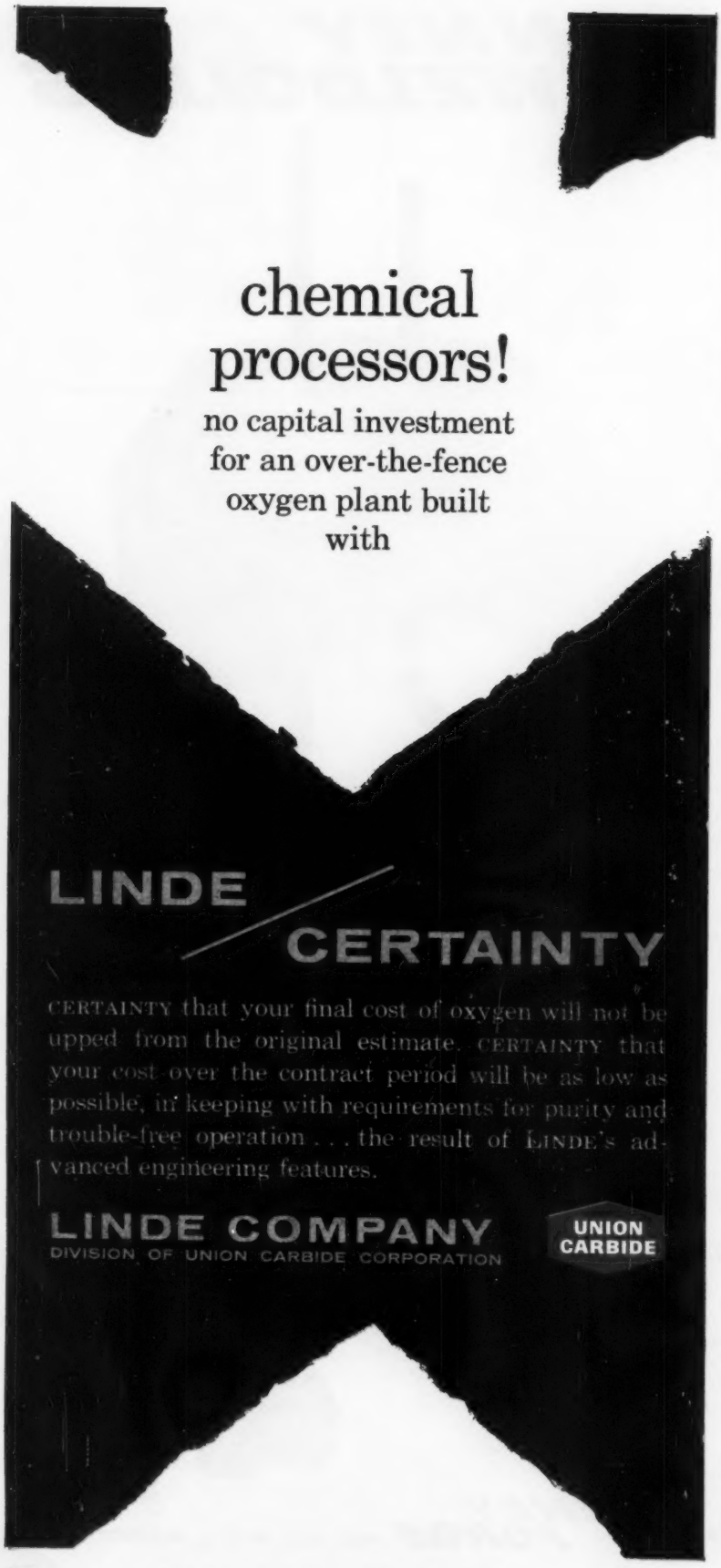
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Men . . .

many patents in plasticizers for vinyl resins, carboxylic acids, and nitrogen and sulfur containing organic compounds.

Ralph A. Cardello has been named assistant director, Process Engineering Division, Esso Research and Engineering Co., at its Florham Park Center. Cardello had been head of the division's project planning section.

Arthur Minich has been elected president, Heyden Chemical Division, Heyden Newport Chemical Corp. Minich succeeds **R. M. Aude,** who died August 20. Since 1955, Minich has been president, Nuodex Products Division, Heyden Newport.

Whelan W. Klemme has been appointed chief chemist, Monsanto Chemical Co.'s Chocolate Bayou project near Alvin, Texas, after serving as chief chemist, Organic Chemicals Division's Anniston, Ala., plant.

William F. Wolff has become senior research scientist, Research and Development Department, American Oil Co., Whiting, Ind. Wolff, who joined the laboratory in 1954, has made contributions to knowledge of the struc-

STATEMENT REQUIRED BY THE ACT OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, JULY 2, 1946 AND JUNE 11, 1960 (74 STAT. 208) SHOWING THE OWNERSHIP, MANAGEMENT, AND CIRCULATION OF HYDROCARBON PROCESSING & PETROLEUM REFINER, published Monthly at Houston, Texas for October, 1961.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Wm. G. Dudley, 29 East Shady Lane, Houston, Texas; Director, Silas B. Ragsdale, 1636 North Blvd., Houston, Texas; Editor, George B. Gibbs, 9214 Timberside Drive, Houston, Texas; Managing editor, Wallace Fitzgerald, 5423 Lymbar Drive, Houston, Texas; Business manager, Robert M. de Sombre, 4410 Ingersoll, Houston, Texas.

2. The owner is: The Gulf Publishing Company, Houston, Texas; June Wooden Bliss, Houston, Texas; June Wooden Dudley Bliss—Trustee, Houston, Texas; Mrs. Grace C. Carter, Dallas, Texas; Margaret Dudley Cashman Trust, Houston, Texas; Drum & Company, c/o Trust Department, Houston, Texas; Fredrica Gross Dudley, Houston, Texas; P. Stinson Dudley, Abilene, Texas; Estate of Ray L. Dudley, Houston, Texas; William G. Dudley, Houston, Texas; William V. Gross, Austin, Texas; Carolyn Dodson Keeble, Abilene, Texas; Anita S. Lane, Houston, Texas; James William Nelson, Baytown, Texas; Tom W. Nelson, Houston, Texas; Obie & Company, Houston, Texas; Sallie Windham Ridley, Corpus Christi, Texas; Walter Gage Sterling, Trustee, Houston, Texas; Edna C. Waller, Chicago, Illinois.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities are: NONE.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: 25,266.

R. M. de SOMBRE
Business Manager

Sworn to and subscribed before me this 4th day of October, 1961.

P. J. AUCOIN
(Seal) Notary Public in and for Harris County, Texas.
(My commission expires June 1, 1963)

ture of organic compounds, charcoal, and other forms of carbon.

H. Robert Sanders, Jr., has been named head of a section in the Products Research Division, Esso Research and Engineering Co. He will be in charge of the section conducting research on finding new applications for petroleum.

Constantine E. Anagnostopoulos has been appointed an assistant director of research for Monsanto Chemical Co.'s Organic Chemicals Division, Nitro, W. Va. He was a scientist with the division's Research Department at St. Louis.

Dr. M. R. Barusch has been appointed senior research associate in chemistry, Petroleum Products Division, Richmond Laboratory, California Research Corp. Dr. Barusch will do research in cool flame oxidation, surface active additives and antidetonants.

Charles Reid Gaylord has resigned as director and senior vice president, Signal Oil and Gas Co. Gaylord, who joined Signal's board as a result of the merger with Hancock Oil Co., will spend more time with management of his personal affairs.

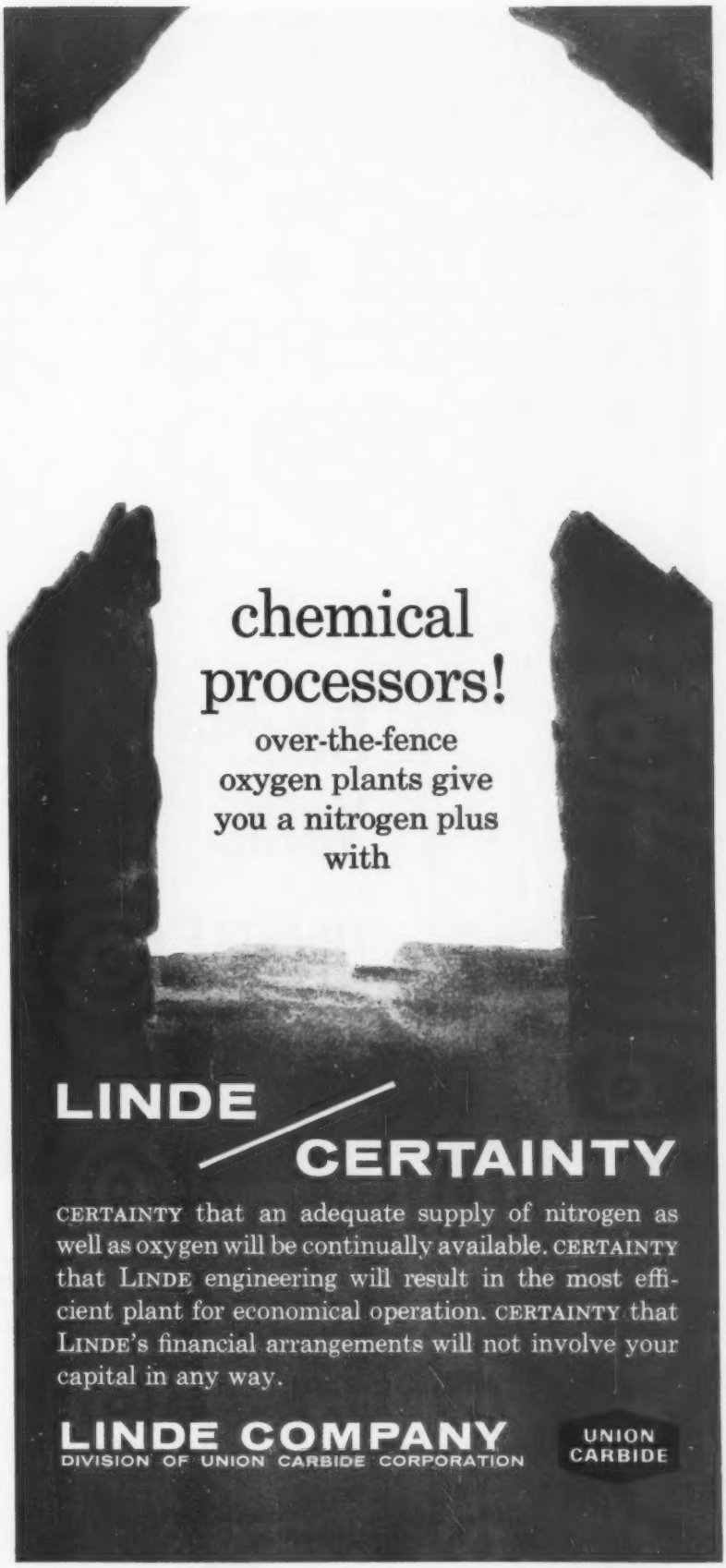
Dr. Roy A. Westlund, Jr., has been promoted to an assistant director, Products Research Division, Esso Research and Engineering Co. Dr. Westlund will be in charge of research on new uses of petroleum and industrial lubricants and greases.

Gerald D. Burt has joined the Whiting, Ind., research laboratories, American Oil Co. He will do research on new compounds to improve motor oils.

James L. Ogilvie has joined Monsanto Chemical Co.'s Research Center at St. Louis, after serving with Shell Oil Co., Deer Park, Texas.

Robert A. Wakefield has joined the process planning section, Richmond Laboratory, California Research Corp., as a research engineer.

Charles A. Burton has been named general supervisor of distribution for Monsanto Chemical Co.'s Chocolate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Men . . .

Bayou project near Alvin, Texas, after serving as an administrative assistant, Engineering Department, Plastics Division's Texas City plant.

Ralph A. Brown has become research associate, Analytical Research Division, Esso Research and Engineering Co. Brown, who joined the division in 1960, does research on general analytical problems.

Fred H. Warren, formerly a senior planning associate for The Ohio Oil Co., Findlay, Ohio, has been named manager, company's Forward Planning Division. Warren joined Ohio Oil in 1939 as assistant chief engineer in pipe line operation.

Howard W. Bell has been elected assistant treasurer, Standard Oil Co. of California. Bell has served seven years with the Iranian Oil Consortium in Abadan, Iran. He joined Standard in 1936 in the Manufacturing Department, El Segundo, Calif.

Dr. Donald L. Guertin has been named assistant director, Analytical Research Division, Esso Research and Engineering Co. He joined Esso Research in 1955.

Dr. Reginald F. Webb has been named director of research, Plastics Division, Allied Chemical Corp. Dr. Webb, who had been director of research and development, Ciba, Ltd., Duxford, England, will headquarter in Morris Township, N. J., at the company's research center.

Dr. Carl E. Heath has been appointed head of the fuel cell section, Products Research Division, Esso Research and Engineering Co. Dr. Heath joined Esso in 1956.

Harold R. Moorhouse, executive vice president and treasurer of Arthur G. McKee & Co., died unexpectedly at Cleveland, Ohio, October 1. Moorhouse had been with Arthur G. McKee since 1929. He had recently been elected administrative executive vice president and a member of a three-man committee set up to handle company operations.

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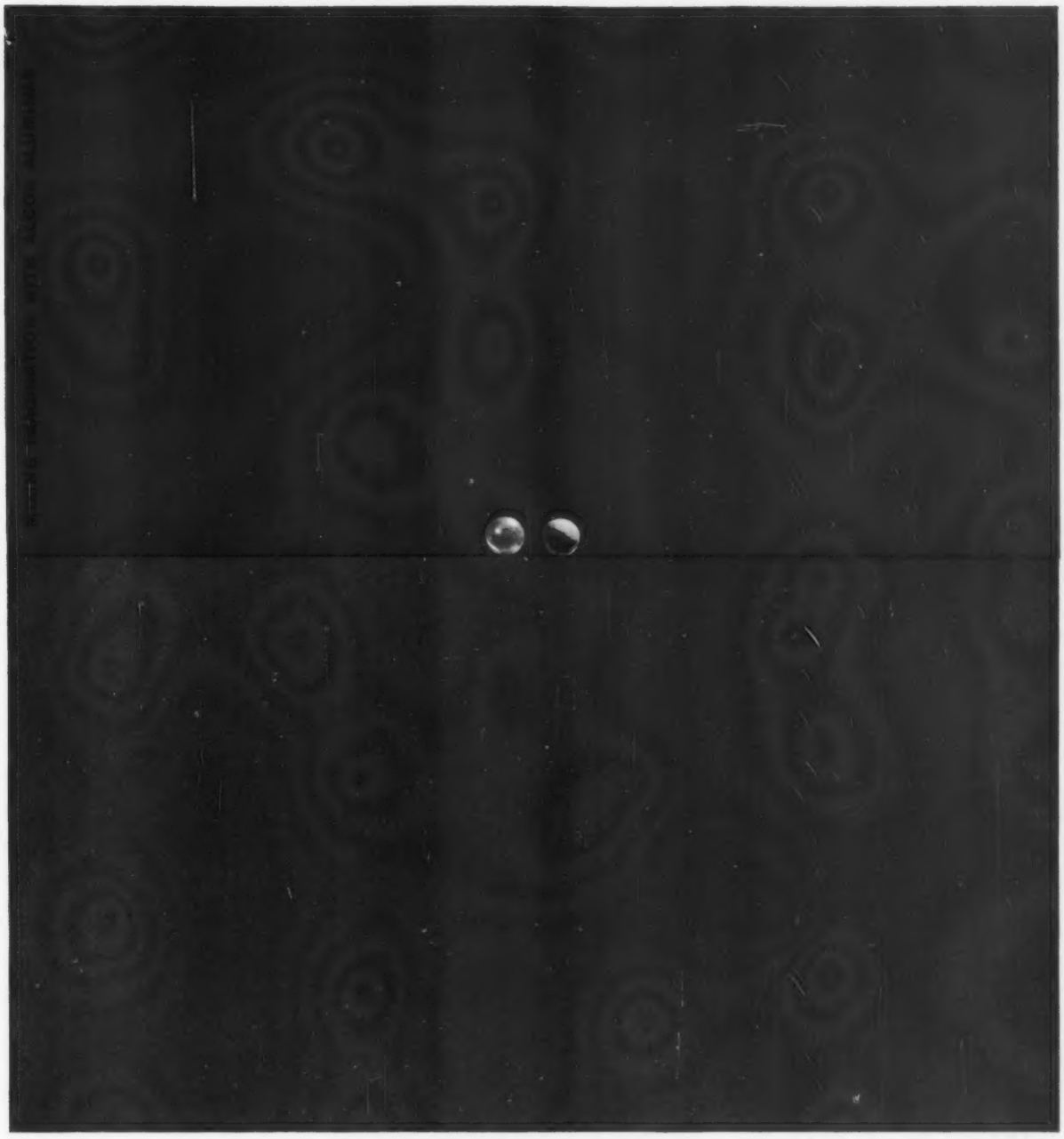

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It's one of a special grade (T-164) of tabular alumina balls developed by Alcoa for pebble heaters, inert supports and covers for catalyst, reactor and desiccant beds.

These smooth-surfaced balls have excellent resistance to both thermal and mechanical shock—as well as good resistance to abrasion.

In heaters where temperature cycles go from 400°F to 2,600°F, there's low loss from spalling and abrasion.

Tabular alumina is a superb heat transfer medium. It has high fusion temperature (3,700°F), good thermal conductivity and high heat capacity. It's also characterized by its chemical inertness and high degree of purity (99.5+%).

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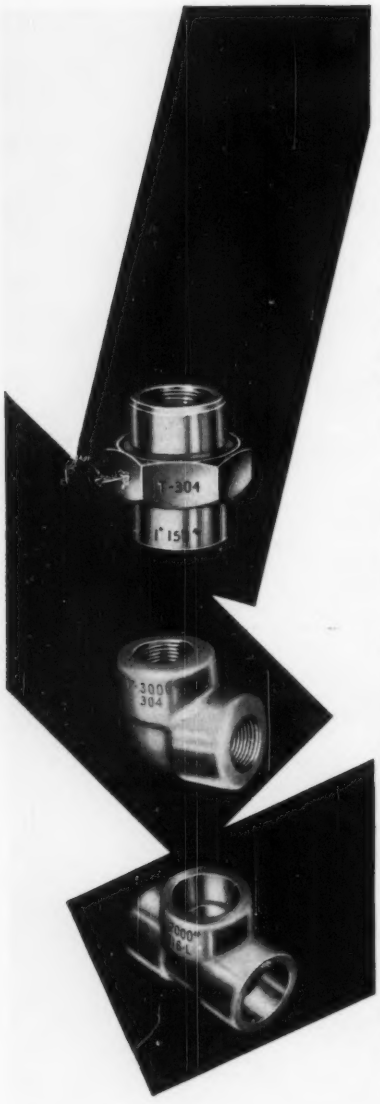

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Challenge of Supervision

Evolves from author's definition of industrial human relations. "The adjustment of unique individuals to their work through selection, training and control of their environments so that they may achieve the greatest job satisfaction while rendering the greatest service to their employers and society." Includes questions, exercises and suggested readings after each chapter.

B. R. Kay, and S. Palmer, *The Challenge of Supervision,* McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y., 246 pages, $4.95.

Leadership, Organization

Complete coverage of the behavioral scientist's approach to leadership and organization. Covers leadership and the influence process; sensitivity training; studies in organization; commentaries on human relations and social psychology in industry; comprehensive bibliography.

R. Tannenbaum, I. R. Weschler, and F. Massarik, *Leadership and Organization,* McGraw-Hill Book Co., 330 West 42nd St., New York 36, N.Y., 456 pages, $7.50.

Cleaning Tanks

Covers use and suitable mechanical equipment and protective measures. *Cleaning Tanks Used for Gasoline or Similar Low-Flash Products,* API Bulletin 2016, Fourth Edition, American Petroleum Institute, Publications Department, 1271 Avenue of the Americas, New York 20, N. Y., 18 pages, $1.

Jet Propulsion Fuels

Includes discussion of fuel properties for turbojet and turboprop engines. Also discusses significance of laboratory tests. Translated from Russian. N. A. Ragozin, *Jet Propulsion Fuels,* Pergamon Press, Ltd., Headington Hill Hall, Oxford, England, 168 pages, $8.50.

Satistical Summary

A supplement to the Chemical Statistics Handbook, Fifth Edition. Wage, hour, employment, production and price trends in the chemical industry as compared with all manufacturing. *Statistical Summary—No. 4,* Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C., 59 pages, $1.

Refractories Industry

Lists by brands and manufacturers 3,548 different refractories for lining industrial furnaces. *Product Directory of the Refractories Industry in the United States,* The Refractories Institute, First National Bank Building, Pittsburgh 22, Pa., 222 pages, $4.50.

Molecular Sieves

Discusses adsorption and commercial uses of synthetic and natural zeolites. Charles K. Hersh, *Molecular Sieves,* Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., 129 pages, $6.50.

National Fire Codes

National Fire Codes Volume 1, Flammable Liquids and Gases, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 1136 pages, $7.

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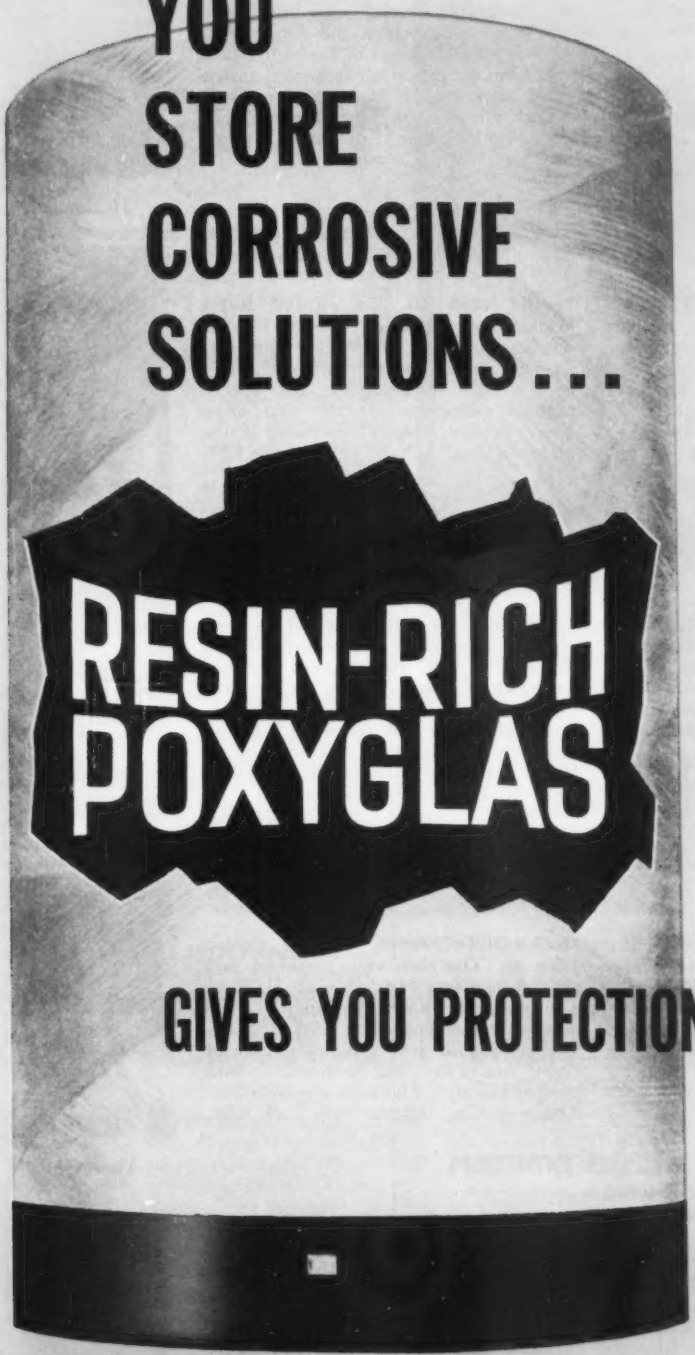

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POXYGLAS™ tanks are Epoxy resin and fiber glas, inside and out. By a unique process, continuous glass fiber filaments are impregnated with resin, then wound on a mandrel. You get protection in depth... protection where it counts! Protection where it pays! With POXYGLAS, you get strength, for the same manufacturing process produces a seamless shell more than twice as strong as steel structures of the same weight, and you get that extra protection of the resin rich interior wall which resists the erosive action of strong chemicals.

What about cost? POXYGLAS tanks cost far less than other structures with the same corrosion resistance. Non-contaminating, corrosion-resistant POXYGLAS tanks are in use now successfully performing holding and storage tasks with such difficult solutions as: Hydrochloric Acid, Phosphoric Acid, Aluminum Sulfate, Sodium Hypochlorite, and other acid and caustic solutions.

If you have a difficult holding or storage problem, a POXYGLAS tank will do the job.

SIZE (dia. x ht.)	5x12	10x8	10x15	12x15	12x20
Nominal Capacity-Gal.	1885	4600	8500	12000	16000
Nominal Capacity-Bbl.	47	110	210	300	400

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Hitch

BABCOCK & WILCOX CO. has named **Joseph Delano Hitch, Jr.,** general manager, international sales, Boiler Division. Hitch is former president and chairman of the board, Dorr-Oliver, Inc. He will handle all international sales for B & W's Boiler Division and will make his headquarters in New York. Hitch joined B & W in September of this year.

FOXBORO CO., LTD., has appointed **Edward R. Huckman** general sales manager. Huckman, who joined the company in 1927 at its main plant in Foxboro, Mass., will have charge of all industrial instrument sales for the Montreal firm in its branch offices in St. John, Toronto, Sudbury, Port Arthur, Edmonton, Calgary and Vancouver, Canada.

Huckman

Ware

HOKE, INC., has appointed **James E. Ware** sales manager. Ware joins Hoke, maker of special purpose fluid control products, after 13 years as resident sales engineer for Chicago Pneumatic Tool Co. Replacing **Ray Moody,** who has resigned to form his own industrial distribution firm in Florida, Ware will direct Hoke's entire sales network.

TRINITY STEEL CO. has named **Royce Walker** sales engineer, Special Product Transport Division. Walker comes to Trinity Steel after working exclusively in the field of cryogenic and special product transports for the past seven years. Trinity recently completed a new plant in Lincoln, Neb., to serve the LPG field.

Walker

Sullwold

ELLIOTT CO. has promoted **John L. Sullwold** to manager of its Los Angeles district. The district covers Southern California, the southern tip of Nevada and the entire state of Arizona. Sullwold, who joined Elliott's parent company, Carrier Corp., in 1949, has been a compressor specialist in Elliott's western region.

BROWN FINTUBE CO., maker of heat exchange equipment, has elected **Robert K. Bissell** secretary. He succeeds the late **Frederick W. Dorn.** Bissell, a Cleveland, Ohio, attorney, was with Dorn's law firm in Cleveland for nine years. He will continue his law practice in Dorn's office. Bissell graduated from Swarthmore College and Harvard Law School.

Bissell

Hatter

FISHER GOVERNOR CO. has assigned **N. J. Hatter** to handle sales representation in the Northern California and Western Nevada areas. Hatter has been with Fisher's main office in Marshalltown, Iowa, since 1946. He spent several years in design engineering before he moved into sales work. He was graduated from Iowa State College.

JOY MANUFACTURING CO. has elected **John W. Thornton** vice president and general manager, Industrial Division. Thornton, who joined Joy in 1957, was previously vice president, marketing. Before coming to Joy, a manufacturer of heavy machinery for construction and general industry, Thornton was with McKinsey & Co., Inc., in New York City.

Thornton

Mindler

THE PERMUTIT CO., a division of Pfaudler Permutit, Inc., has made **A. B. Mindler** manager of special applications sales, Industrial Division. Mindler returned to Permutit in September from the Ionac Chemical Co., another division of Pfaudler Permutit, where he was associate director of research-administration for the last year and half.

LUKENHEIMER CO., Cincinnati, Ohio, manufacturer of valves, has appointed **John L. Rice** sales representative. He will cover sales in West Texas, including El Paso, Borger and Pampa, and all of New Mexico. Rice, who will headquarter in Midland, Texas, was with Walworth Co. for 25 years in sales. He graduated from the University of Illinois.

Rice

AMERICAN METER CO. has named **Stuart J. Northrop** director of manufacturing. Northrop was with SKF Industries, Inc., and Westinghouse Electric Corp. before joining American Meter.

PACKARD BELL COMPUTER CORP., a division of Packard Bell Electronics, has assigned **Richard F. Musson** to computer products as sales manager. Musson will direct sales of general purpose digital computers.

CORNING GLASS WORKS has appointed **Peter Davenport** eastern district salesman. Davenport, who will headquarter in Philadelphia, joined Corning in 1960 in the central sales district.

HAGAN INDUSTRIES, INC., has elected **J. J. Wuerthner, Jr.,** vice president and assistant to the president. Wuerthner was formerly a consultant with General Electric Co. in New York City.

COOK PAINT AND VARNISH CO. has been made exclusive sales and service representatives for galvanic protective coatings made by Industrial Metal Protectives, Inc., Dayton, Ohio. Cook will serve a 14-state area from Canada to the Gulf of Mexico, including states from North Dakota to Michigan to Texas and Louisiana.

HILLS-McCANNA CO. has named **Paul McCloud** manager of distributor sales. Formerly industrial sales manager for the company, he has been with Hills-McCanna for six years.

ARTHUR D. LITTLE, INC., has opened its Mexican subsidiary, Arthur D. Little de Mexico, S.A. **Richard L. Bolin** will be in charge of the offices located at Paseo de la Reforma 116-804, Mexico 6, D.F.

AKRON METALLIC GASKET CO. has appointed **James A. McElroy** general sales manager. McElroy, who came to the firm in 1959, previously divided his duties as sales manager and production manager.

JONES & LAUGHLIN SUPPLY DIVISION has appointed **Thomas L. Webb** manager, advertising and marketing research. Webb came to J & L in 1959 as a sales trainee. He has been in the firm's general products and tubular products sales sections at Tulsa, Okla.

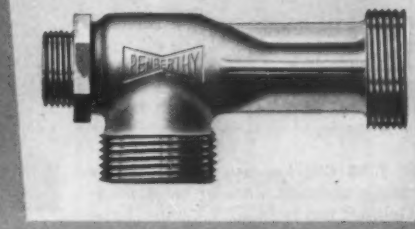
CHASE BRASS & COPPER CO., subsidiary of Kennecott Copper Corp., has named **Thomas E. Anding** manager, Chase Metal Service Division, Dallas, Texas. **C. D. McCarra** has been assigned to Chase's Mill Division, Dallas.

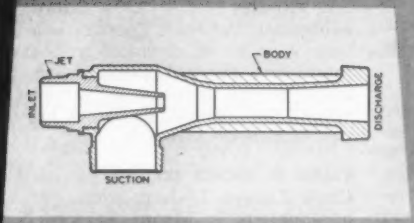
CONSOLIDATED ELECTRODYNAMICS CORP. has appointed **S. Frank Buck** sales promotion manager. Buck, who joined CEC in 1956, has been a divisional advertising manager for the past four years.

KIELEY & MUELLER, INC., Middletown, N. Y., manufacturer of control valves for the processing industry, has signed a licensing agreement with Sidel—Comercio E Industria S.A. to make its complete

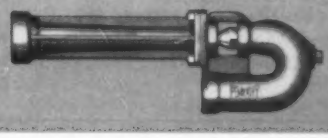
VERSATILITY

for applications unlimited





JET PUMPS by PENBERTHY



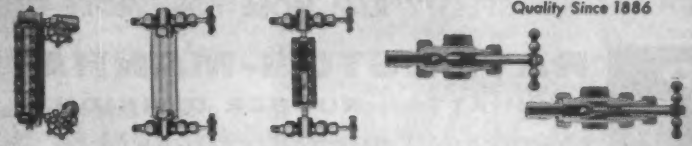
There's hardly a basic manufacturing or service industry that hasn't a use for Penberthy Jet Pumps. And the list of OEM products embodying Jet Pump applications is virtually endless, too. Small wonder, for wherever there's a fluid, vapor, gas or slurry handling job to be done . . . aerate, agitate, blend, circulate, dilute, exhaust, filter, heat, mix, pump or transfer . . . there you'll find an application for *versatile* Penberthy Jet Pumps.

And consider the advantages . . . small in size, light in weight . . . construction and operation simplicity . . . low initial cost, low installation cost, little or no maintenance cost. And in many cases Penberthy Jet Pumps can be utilized where mechanical pumps are impractical or uneconomical. Want more information? Send the coupon below or call your nearby Penberthy engineer today.

PENBERTHY MANUFACTURING COMPANY
Division of Buffalo-Eclipse Corporation
PROPHETSTOWN, ILLINOIS
SALES OFFICE: 2660 E. GRAND BLVD., DETROIT 11, MICH.

PENBERTHY
Dedicated to Quality Since 1886

PENBERTHY FOR LIQUID LEVEL GAGE SETS, TOO



WRITE OR CALL PENBERTHY TODAY FOR COMPLETE INFORMATION

For more data on advertised products, use cards, last page.

Suppliers . . .

line of automatic control valves and level controllers. Sidel—Comercio E Industria, a Brazilian firm, will produce the Kieley & Mueller product line for the South American market.

ATLANTIC METAL HOSE CO. has assigned **James J. Egan** to its New York office as sales correspondent. Egan had been assistant to the sales manager, Packless Metal Hose, Inc., for 10 years before joining Atlantic.

PACIFIC TUBE CO. has appointed **Arthur C. Geldner** assistant general sales manager. Geldner has been with Pacific Tube since January 1954. **Louis Spitsen** replaces Geldner as manager, bar sales. Spitsen joined the company in November 1953.

CORNING GLASS WORKS has elected **Amory Houghton** chairman of the executive committee. He has been board chairman since 1941. **William C. Decker,** company president since 1946, has replaced Houghton as board chairman and chief executive officer.

COOPER-BESSEMER CORP. has made **R. King Egger** sales engineer. Egger was with Cooper-Bessemer from 1951 to 1953. He was in the U.S. Air Force from 1953 until rejoining C-B on August 1 of this year.

PATTERSON FOUNDRY AND MACHINE CO. has formed a new subsidiary, Process Equipment Trading Co. Patterson Foundry and Machine, through Process Equipment Trading, will take in surplus equipment as partial payment on new

Crossley

Brown

equipment. Patterson Foundry is a longtime supplier of chemical processing machinery. **Howard Crossley** has been made general manager of the new division, and **Norman E. Brown** has been named assistant manager.

RALPH N. BRODIE CO. has named **A. S. Clark** Eastern Division manager with headquarters in Mount Vernon, N. Y. Clarke will handle both sales and service of Brodie meters and control valves throughout the eastern and southern seaboard market areas.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has appointed **Richard T. Waits, Jr.,** eastern regional industrial manager with headquarters in Long Island City, N. Y. He succeeds **D. W. Fryback,** who has become account executive at Hartford, Conn. Waits will handle sales of industrial process instruments and control systems in New England, Northern New Jersey and most of New York state.

LA SALLE STEEL CO. has made **Robert Peterson** manager, steel service center sales. La Salle Steel's headquarters are at Hammond, Ind.

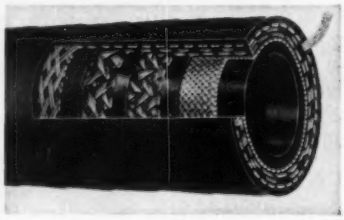
PRECISION SCIENTIFIC CO. has named **Bernard E. Therrien** district sales manager of the Cleveland, Ohio, territory. Therrien will handle sales in Ohio, West Virginia, Kentucky, Western Pennsylvania, Western New York and Eastern Michigan.

VISCO PRODUCTS CO., producer of chemicals for the oil industry, has opened new offices and a laboratory at Sugar Land, Texas, 20 miles southwest of Houston. The new $750,000 office and laboratory building contains 25,000 square feet of floor space.

S & S ASSOCIATES, INC., technical representatives, has opened a branch office in Cincinnati, Ohio. **Harold Lorber,** field engineer for the Cincinnati-Dayton area, will be office manager.

HEAD WRIGHTSON STOCKTON, LTD., has appointed **J. D. Eccles** director and general manager. **G. F. Taylor** has been named general manager, Head Wrightson

R/M HOSE . . . *First for Service*



at the Refinery

Non-Burst SUPER-MASTER BW Steam Hose

- Practically Burst-Proof
- Static Wire
- Steel Wire Braid Reinforced
- Butyl Cover
- For Pressures to 200 lb—(388° F)

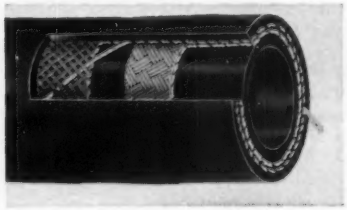
Preferred by safety engineers for flash-fire protection, clean-up . . . for temporary dock-to-ship steam lines to clean vessels and tank cars. Maximum strength and flexibility . . . maximum safety. Made with neoprene cover to stand heat and weather. Write for Bulletin M630.

for Industrial and Home Delivery

Underwriters' Labeled HOMOFLEX PROPANE Hose

- Light, Flexible as a Rope
- Mandrel Made, Kink-Proof
- Braid Plies
- Stainless Steel Static Wire
- Hycar Tube, Neoprene Cover

Easiest hose to handle from tank truck to supply tank. Labeled by Underwriters. Meets specifications of state regulations covering use of liquid petroleum gases. Uniform inside and outside diameters for safer, easier coupling. Write for Bulletin M630.



SPECIFY R/M HOSE FOR "*MORE USE PER DOLLAR*"

RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION • PASSAIC, N. J.

ENGINEERED RUBBER PRODUCTS

RM-130

Steel Foundries, Ltd. **A. J. Long** has joined Head Wrightson Export Co. as general manager. The three companies are divisions of Head Wrightson & Co., Ltd., London.

CONTINENTAL-EMSCO CO. has named **Phillip J. Liston** sales manager, Fibercast Co., manufacturer of reinforced epoxy resin pipe and fittings. Liston, former assistant sales manager in charge of special projects for Fibercast, joined Continental-Emsco in 1957. Fibercast is operated by Continental-Emsco.

DARLING VALVE & MANUFACTURING CO. has appointed **John B. Moriarty** sales representative, New York eastern regional office. Before joining Darling Valve, Moriarty was a sales engineer for Champion Electric Co. and Westinghouse Electric Corp. in New York.

MAJOR FURNACE AND COMBUSTION ENGINEERS PTY., LTD., Melbourne, Australia, has been licensed to build and sell Selas Corp.'s heat processing equipment for the petroleum and chemical industries in Australia.

U. S. INDUSTRIES, INC., has elected **Sanford B. Kaynor** secretary. Kaynor, who joined USI in 1958, became assistant secretary in 1959.

A. O. SMITH INTERNATIONAL S. A. has named **Albert W. Rouse** product manager for fluid measuring equipment. Before joining AOSSA, Rouse was in A. O. Smith's Houston office specializing in the petrochemical and oil industries.

BABCOCK & WILCOX CO. AND YOUNGSTOWN SHEET & TUBE CO. have joined forces to produce and sell low-cost piping materials. The two companies will make welding fittings and flanges of an alloy which, according to the firm, is lower in cost and resists corrosion better than wrought iron.

KAISER STEEL CORP. has transferred **Donald B. Hicks** from its Oakland, Calif., office to Fresno, Calif., as resident sales representative. Hicks joined Kaiser's Sales Department in 1953.

ARMOUR INDUSTRIAL CHEMICAL CO. has appointed **Karl M. Bierman** manager, marketing staff. Bierman, formerly eastern regional sales manager, joined Armour in 1954. He had been eastern regional sales manager since 1958.

THOMPSON RAMO WOOLDRIDGE, INC., has named **Robert J. Nelson** district manager, eastern region, TRW Computers Co. Before joining TRW, Nelson was with Information Systems, Inc.

GUSTIN-BACON MANUFACTURING CO.'s vice president, **F. W. Muller,** has been elected president, National Insulation Manufacturers Association. He replaces **Emil T. Johnson,** vice president, Union Asbestos & Rubber Co. **M. W. Burleson,** vice president, Johns-Manville Sales Corp., has been re-elected vice president of NIMA.

THORNHILL-CRAVER CO., Houston, has named **H. O. Duncan** sales representative in Lafayette, La. **James B. Wilkerson** has

Duncan

Wilkerson

been appointed to represent the firm in Arkansas, North Louisiana and Mississippi.

OWATONNA TOOL CO. has appointed **Howard D. Haugen** district manager for a 10-county area south of San Francisco, Calif. Haugen will be working with the Tools & Equipment Division.

BORG-WARNER CORP. has named **Frank A. Flower** manager, Washington, D. C., office. Flower has been manager of Thompson Ramo Wooldridge, Inc.'s, Washington office for many years.

BALDWIN-LIMA-HAMILTON CORP. has elected **Henry F. Barnhart** to the executive staff as vice president in charge of sales, construction equipment. **Charles M. Lippincott,** vice president and general manager, the company's plant at Aurora, Ill., succeeds Barnhart as vice president and general manager, Construction Equipment Division.

CONTROLS FOR RADIATION, INC., Cambridge, Mass., has appointed **Robert C. Fraser** sales manager. Fraser was with Harbridge House, Inc., management consulting firm, before joining Controls for Radiation.

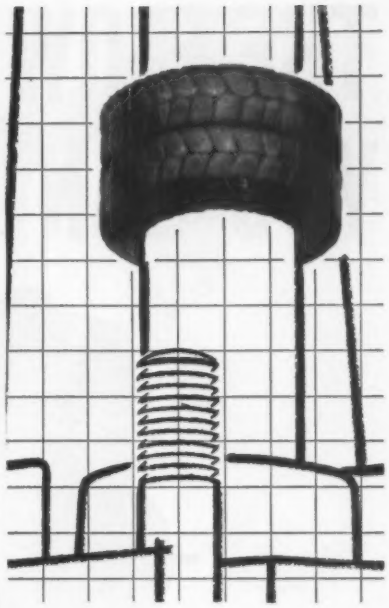
DOVER CORP. has elected **Otto G. Schwenk** president. Schwenk succeeds **Fred D. Durham,** who has been named chairman of the board and who will continue as chief executive officer.

DRESSER INDUSTRIES, INC., has elected **John P. Cartwright** vice president, machinery group. Cartwright comes to Dresser from Joy Manufacturing Co. where he was a vice president and general manager, Industrial Division.

BORG-WARNER INTERNATIONAL CORP. has elected **Alonzo B. Kight** president. He has been with Borg-Warner since 1948. Kight has been vice president of Borg-Warner International since 1955.

AUTOMATIC CONTROL ENGINEERING, LTD., has opened a new design office at 15 Bloom St., Manchester, England. **R. S. Seagrave** is office manager.

UNITED STATES STEEL CORP.'s National Tube Division has elected **William C. French, Jr.,** vice president, sales. French, who has been general manager, sales, re-



R/M Capability Produces Asbestos-Teflon* Packings

with low breakaway friction and excellent resistance against most solvents, acids and other chemicals

When you install R/M Nos. 840SW and 840SB braided and "Teflon"-impregnated packings or R/M No. 848 "Teflon" filament packing on your valves and pumps you can forget the troubles normally associated with acids and corrosive fluids. They represent the most effective combination of materials for resisting solvents, acids and other chemicals—high grade asbestos yarn and "Teflon." And they eliminate the need for lubricants that might contaminate the materials handled. They are specified as original packings by many manufacturers of chemical-handling valves and pumps.

R/M No. 840SW is designed primarily for use in pumps and valves handling solvents, R/M No. 840SB is most effective in resisting strong acids and corrosive fluids, R/M No. 848 is usually applied where strong and concentrated acids, solvents and slurries are conveyed.

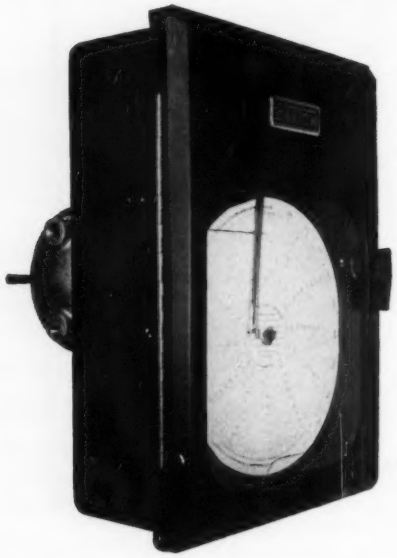
We will be glad to recommend packings for any special requirements you may have. Consult us—and send for a copy of our new Catalog P-100 containing complete information on R/M Mechanical Packings and Gasket Materials.

*Registered trademark for DuPont fluorocarbon resins

RAYBESTOS-MANHATTAN, INC.
R/M PACKINGS
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

For more data on advertised products, use cards, last page.

THE FLOW RECORDER YOU CAN COUNT ON



Absolute dependability, under the most demanding operating environments—that's the promise and the performance of the Barton 202A flow recorder. Thoroughly proven in the gas production fields, the 202A is enjoying ever-increasing popularity in gas transmission and distribution systems. It is compact and ruggedly built, not subject to the usual frailties of such a precise instrument; it has built-in overrange protection, and it is immune to condensate problems, making it ideal for application in all geographical areas. A recently added bonus: the 202A can be fitted with the new Barton chart changer which allows the instrument to record continuously and unattended, for up to 16 days, using a fresh chart each day. For complete information and specifications on the 202A flow recorder, request Bulletin 202A-1.

BARTON

RECORDER-INTEGRATORS/CONTROLLERS/DIFFERENTIAL PRESSURE INDICATORS/PNEUMATIC TRANSMITTERS/FLOW SWITCHES

BARTON INSTRUMENT CORPORATION • MONTEREY PARK, CALIFORNIA

Suppliers . . .

places **Robert E. Williams,** who has resigned. **Arthur J. Elbert, Jr.,** formerly manager of sales, pipe lines, National Tube Division, has been named to succeed French as sales general manager.

JONES & LAUGHLIN SUPPLY DIVISION has appointed **Julius Nemeth** district store

Nemeth

Seeker

Atyia

manager at Morgan City, La. He was previously salesman at Harvey, La. **W. H. Seeker, Jr.,** has been promoted to district store manager at Hobbs, N.M. Seeker was transferred from Snyder, Texas. **Haney Atyia,** salesman at Midland, Texas, has been made store manager at Snyder, Texas. Nemeth joined Jones & Laughlin in 1946. Seeker came to the company in 1943, and Atyia joined J & L in 1950.

B-I-F INDUSTRIES, specialists in equipment and engineering systems for process industries, has become a division of New York Air Brake Co. B-I-F Industries will continue to headquarter in Providence, R. I., under the same management.

SCHIELD BANTAM CO., Waverly, Iowa, has appointed **Vernon E. Pray** domestic sales manager. Pray came to Schield Bantam in 1949 from R. G. Le Tourneau, Inc., Peoria, Ill.

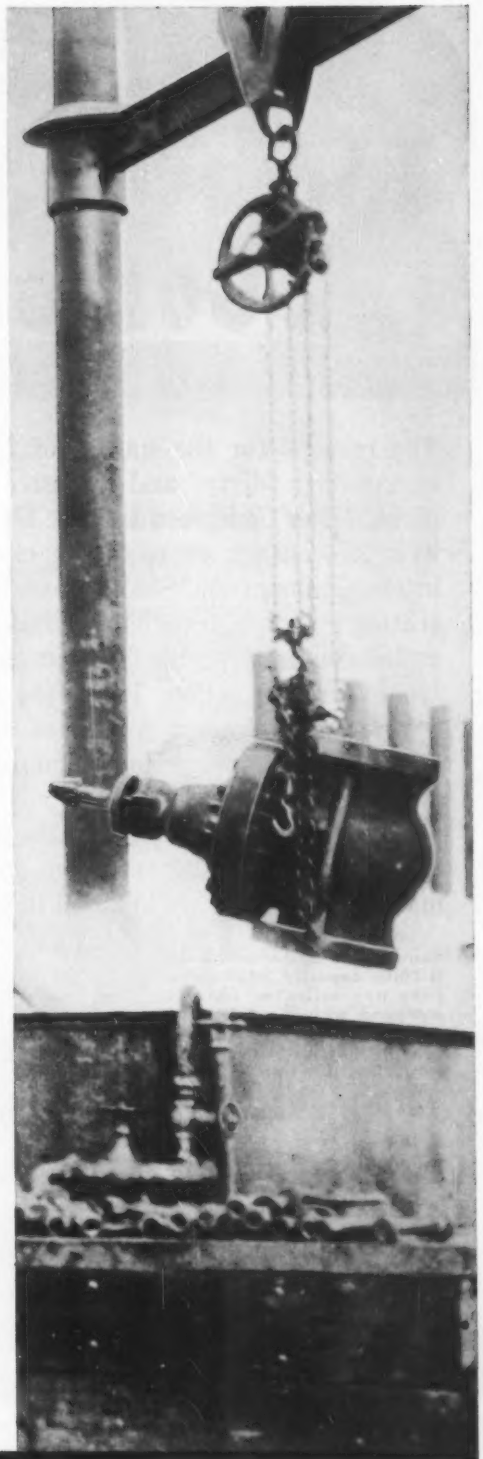
RAYTHEON CO. has named **James D. Bowen** sales manager, Sorensen product lines. Before joining Raytheon, Bowen was eastern sales manager for Sola Electric Co. and a sales engineer for Sorensen & Co., Inc.

BORG-WARNER CORP. has appointed **Morton B. Millenson** manager, economic research. Millenson joined Borg-Warner's Roy C. Ingersoll Research Center in 1957, serving first as a scientist and later as manager of project administration.

UNION PUMP CO. will set up a company in Japan to make pumps for distribution in the Far East. The new firm, Union Pump (Japan), Ltd., is a joint venture

Oakite ECP
engineered cleaning program

turns parts salvage into a BIG source of savings



Salvage cleaning of flanges, fittings, valves and other parts formerly took up to 22 hours a batch at one refinery. Heavy deposits of grease, paint, oil and rust were being stripped with a cold solvent. The effort seemed hardly worthwhile.

But in developing an ECP for the refinery, the Oakite engineer included a recommendation to install a permanent salvage cleaning set-up. Now, parts reclamation is a strong contributor to cost control. Work moves as in a "production line"...through special Oakite solutions. Stripping even the worst of soiled batches to bare metal takes only an hour and a half... while material costs have been cut from $1.90 a gallon to less than 58 cents!

WHAT IS OAKITE ECP? It's an *Engineered Cleaning Program* that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by *materials* known to make short work of refinery soils, by proved *methods*. Send for booklets. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

OAKITE
SCIENCE
over 50 Est. 1909 years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

For more data on advertised products, use cards, last page.

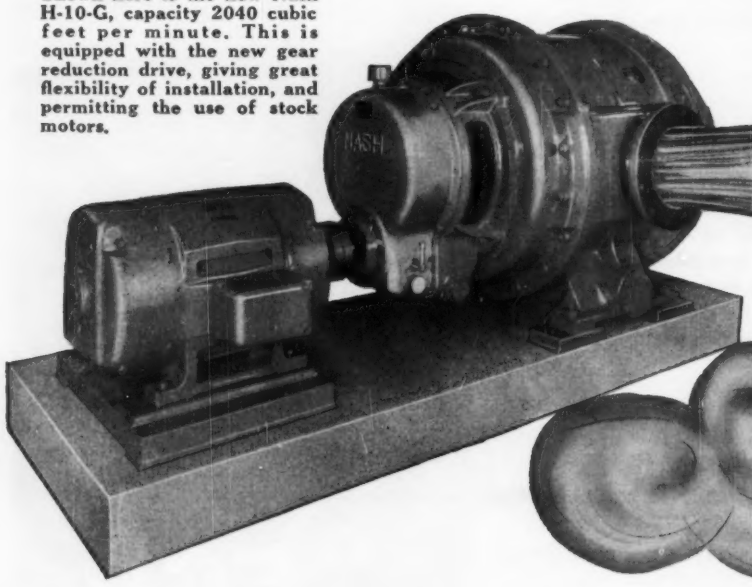
Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

Nash Vacuum Pumps offer the same basic advantages when handling corrosive gases, and reliably maintain vacuums up to 29.50 inches of mercury.

ACETONE
ACETYLENE
AMMONIA
ARGON
BUTADIENE
CARBON DIOXIDE
CARBON MONOXIDE
CHLORINE
ETHYL CHLORIDE
FLUE GAS
FURFURAL
HEXANE
HELIUM
HYDROGEN
HYDROGEN SULPHIDE
NITROGEN
OXYGEN
PHOSPHOROUS PENTOXIDE
SULPHUR GAS
VINYL ACETATE
VINYL CHLORIDE
AND MANY OTHERS

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

Suppliers . . .

by Union Pump and Dengyosa Machine Works, Ltd., of Tokyo. Union Pump's U.S. headquarters are at Battle Creek, Mich.

HILLS-McCANNA CO. has named **Joseph E. Clermont** controller. Clermont was formerly treasurer of Inland Steel Container Co., Chicago.

CHICAGO PNEUMATIC TOOL CO., has elected **Thomas F. Noonan** a vice president. With the company for more than 20 years, Noonan will continue as comptroller, which he has been since 1959.

Noonan

Lane

Carra L. Lane, manager of plant operations, has also been promoted to a vice president.

BAILEY METER CO. has named **G. R. Mays** manager, north central region. Mays, formerly manager of the Chicago district, will cover Chicago, Cincinnati, Cleveland, Detroit, Milwaukee and St. Paul areas. Mays joined Bailey Meter in 1930.

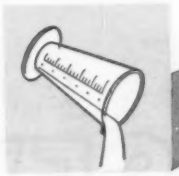
BURGESS-MANNING CO. has made **E. H. Parker** sales engineering representative for Colorado, Wyoming and Utah. Parker, formerly with Oklahoma Natural Gas Co., will serve the refinery and chemical industries from his headquarters in Denver, Col.

A. O. SMITH CORP. has changed the name of its Reinforced Plastics Division to Glass Fiber Products Division. The company headquarters are at Milwaukee, Wis.

SOLAR AIRCRAFT CO. has named **R. A. Caso** sales engineer for turbomachinery in the northeast section of the United States. Caso, who will be located in Livingston, N. J., was with Marathon Electric Co. before joining Solar.

PERMUTIT CO., division of Pfaudler Permutit, Inc., has opened a new industrial sales office in Dallas, Texas. **Austin F. McCormack** is office manager.

MILTON ROY CO., maker of controlled volume pumps and chemical instrumentation systems, has promoted **H. Rodman Smith** to sales manager, Instrument Division. **A. W. Lubbers** and **John A.**



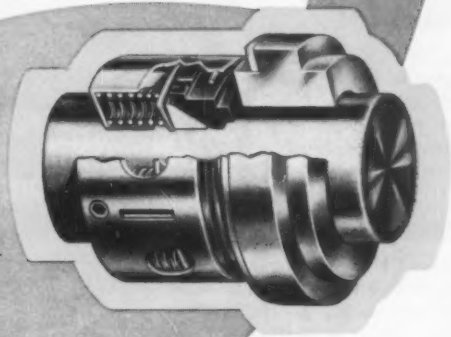
ACIDS, CORROSIVES AND SOLVENTS

HOT LIQUIDS

TOXIC GASES AND VAPORS

JOHN CRANE

TYPE 9 MECHANICAL SEAL



WILL HANDLE THEM ALL!

Wedge and sealing rings molded from DuPont Teflon assure efficient, safe handling of industrial chemicals and corrosives at temperatures from −120°F. to +500°F. on many services. Spring and metal parts are furnished in the metallurgical specification best suited to the particular service. In every way, you get a mechanical seal that is "John Crane" engineered to your requirements—no matter how tough!

The Type 9 Seal has and continues to solve innumerable problems where difficult-to-handle liquids and gases are involved . . . at pressures up to 750 psi. It can do the same for you.

Use the Type 9 Seal on all rotating shaft equipment—centrifugal and rotary pumps, mixers, agitators, autoclaves, other equipment.

REMEMBER: *Your toughest problem can be the Type 9's next success story.* Send for full details today.

Crane Packing Co., 6420 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

CRANE PACKING COMPANY

For more data on advertised products, use cards, last page.

SEVEN SERVICES

THAT CONVERT YOUR NEW-PLANT COST INTO A PROFIT-EARNING INVESTMENT

ANALYSES AND REPORTS

Complete, detailed information on all factors affecting your project is thoroughly analyzed and evaluated to give you accurate, comprehensive data to provide a sound basis for your decision.

SELECTION OF PROCESS DESIGN

Modern electronic data-processing equipment enables our technical experts to make exhaustive explorations of all possibilities to select the economic optimum combination for your plant.

ESTIMATES AND PROPOSALS

A thoroughly detailed bid, submitted on either a lump-sum or cost-plus-fee basis, tells you clearly and exactly what we propose to do, how we will do it, how long it will take and how much it will cost.

ENGINEERING

The specialized knowledge and practical experience of experts in every applicable branch of engineering are brought to bear on your project by the large, diversified McKee-WKE engineering staff.

PURCHASING

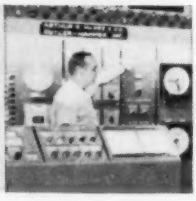
From long experience our purchasing men know how to get the right materials and equipment, from the right sources, at the right price, inspected and on the job at the right time—anywhere.

CONSTRUCTION

Our field engineers know how to build your plant to specifications, on schedule, within the budget. They know your local customs and conditions—how to employ local labor to your advantage.

START-UP AND OPERATION

McKee-WKE engineers will help your own staff put the plant in operation. We can also hire or train competent operators for you, or negotiate a contract for management of your new plant.



McKee-WKE engineers can supply any or all of the specialized engineering and construction services necessary to design, build and equip your complete plant—from its earliest inception to final completion and initial operation. You deal with *one* experienced, responsible organization, sign *one* contract—and we do the rest. We assume complete responsibility for the entire project. This frees you and your personnel from the necessity of multiple contract negotiations with sub-contractors and the consequent division of responsibility. From preliminary planning to producing plant, every detail of your project is in the capable hands of a versatile, experienced staff that can deliver the results you want anywhere in the world. A call to any McKee or WKE office will bring you convincing evidence of how each of our seven services can work effectively for you.

THE McKEE ORGANIZATION **ARTHUR G. McKEE & COMPANY**, 2300 Chester Ave., Cleveland 1, Ohio. *Offices:* New York, N. Y.; Union, New Jersey; Washington, D. C.; *Subsidiaries:* Toronto and Montreal, Canada; Mexico City, Mexico; Sao Paulo, Brazil; Buenos Aires, Argentina; McKee Head Wrightson, London. **WESTERN KNAPP ENGINEERING CO.**, 650 Fifth St., San Francisco 7, Calif. *Offices:* New York; Chicago; Hibbing, Minn.

INTERNATIONAL ENGINEERING AND CONSTRUCTION SERVICES

Suppliers . . .

Mitchell, Jr., have been appointed sales manager and assistant sales manager, respectively, in the Mechanical Products Division.

LUKENHEIMER CO. has named **Richard B. Sines** and **Joe Kaye** sales representatives. Sines, who will headquarter in Charleston, W. Va., will cover West Virginia,

Sines

Kaye

Southern Ohio and Eastern Kentucky. Kaye will serve the Southeast Texas and Southwestern Louisiana areas from Houston.

UNITED STATES RUBBER CO. has appointed **Edwin D. Meade** director of commercial relations. Meade will assist in the development of national accounts which use products of two or more of the company's divisions.

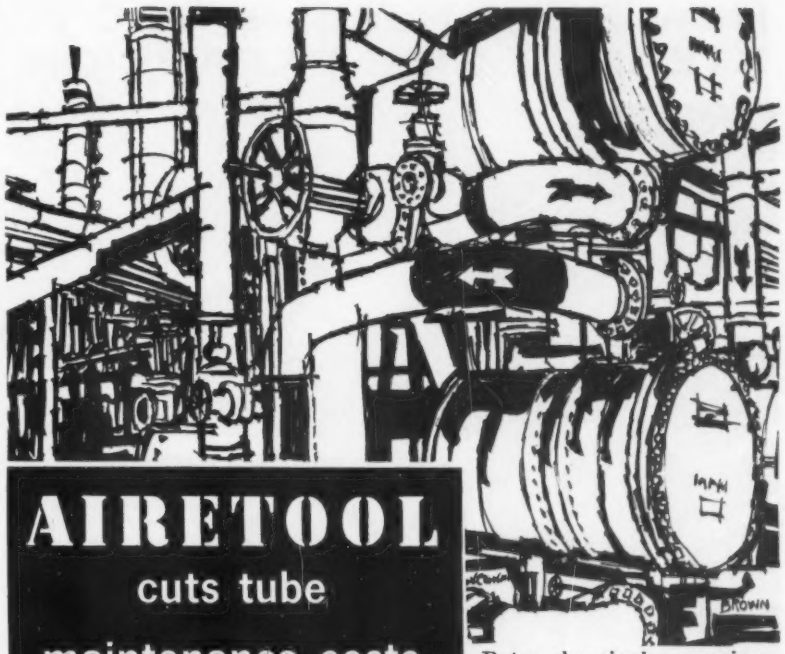
WORTHINGTON CORP. has named **Patrick L. McManus** general manager, Standard Pump Division, at East Orange, N. J. He was formerly director of marketing services at the company's headquarters in Harrison, N.J. McManus, who joined Worthington in 1936 has served as a general line salesman in Spokane, Wash., and Cleveland, Ohio. He became assistant general sales manager and eastern regional sales manager in 1959. He was appointed director of marketing services in 1960.

McManus

ARMOUR INDUSTRIAL CHEMICAL CO. has promoted **E. L. Rhoads** to eastern regional sales manager. Rhoads, who will headquarter in Lodi, N.J., joined Armour in 1951 as a salesman, and became western sales manager in 1960.

HOKE, INC., has appointed **Harold P. Scheinkopf** manager of market research. Before joining Hoke, Scheinkopf was manager of marketing for Tube Distributors Co., Inc.

THOMPSON RAMO WOOLDRIDGE, INC., TRW Computers Division, has named **Robert E. Richards** district manager, eastern region. Richards, who will head-



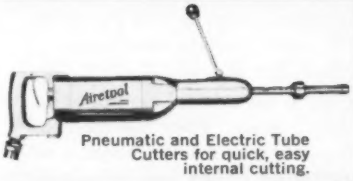
AIRETOOL
cuts tube
maintenance costs
for petro-chemical
processors, too . . .

Petro-chemical processing demands efficient tubular equipment. Plugged tubes eat up profits. That's why more processors rely on Airetool pneumatic tube maintenance equipment to maintain production schedules; reduce down time with this modern equipment.

AIRETOOL MAKES

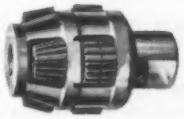
Expansion Controls . . . both pneumatic and electric . . . for fast, accurate rolling of large and small tubes.

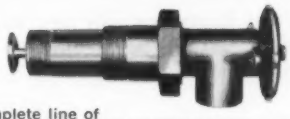
Air Powered Heat Exchanger and Condenser Cleaners . . . with built-in flushing systems . . . to meet every need.



Pneumatic and Electric Tube Cutters for quick, easy internal cutting.

Cleaner Heads . . . including Brush Head Cleaners . . . for straight or curved tubes.





Complete line of tube maintenance Accessories.

Pneumatic Production Tools to speed tear-down and assembly.

Check our Bulletin 74 in the 1961 Refinery Catalog. Ask your Airetool representative for your copy . . . or, write us direct.

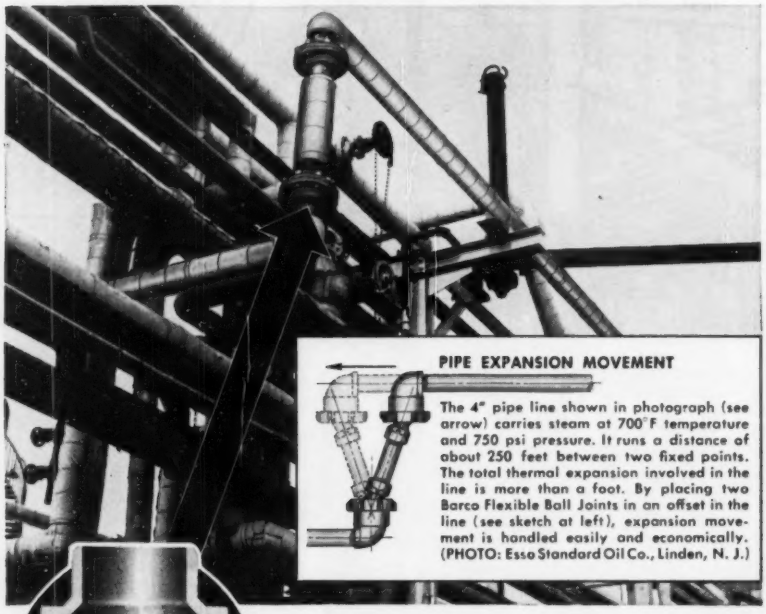
AIRETOOL
MANUFACTURING COMPANY
• SPRINGFIELD, OHIO

Representatives in principal cities of the free world

More than 30 years' experience in pneumatic motor equipment

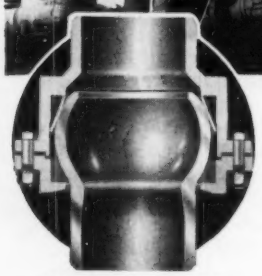
For more data on advertised products, use cards, last page.

How Plant Handles 700°F. STEAM . . . PIPE EXPANSION



PIPE EXPANSION MOVEMENT

The 4" pipe line shown in photograph (see arrow) carries steam at 700°F temperature and 750 psi pressure. It runs a distance of about 250 feet between two fixed points. The total thermal expansion involved in the line is more than a foot. By placing two Barco Flexible Ball Joints in an offset in the line (see sketch at left), expansion movement is handled easily and economically. (PHOTO: Esso Standard Oil Co., Linden, N. J.)



BARCO HT HIGH TEMP. Flexible BALL JOINTS

SAVE VALUABLE SPACE

ADVANTAGES:

SAVE SPACE — Barco Ball Joints are used to perform functions similar to U-bends or pipe loops — But with much less space required and often LOWER COST.

NO PRESSURE THRUST —Expensive anchoring or bracing not required to hold piping in place or in line.

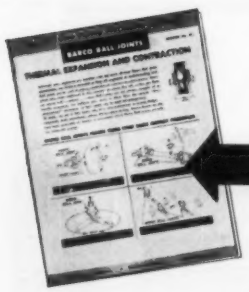
HIGH TEMPERATURE, PRESSURE — Wide choice of materials in new Barco HT Joints.

SIMPLE — Eliminates much tedious pipe stress analysis calculation.

The Barco HT (High Temperature) Flexible Ball Joint is a new development. It is *the key* to solving many PIPE EXPANSION PROBLEMS where high temperatures and pressures are encountered. HT joints can be supplied in sizes from 2" to 16", angle or straight, and can be fabricated from materials to withstand as much as 1000°F, 1200°F, or even 1400°F, under certain conditions.

Rugged "Fire-Safe" Barco joints have no thin wall sections, no critical points of fatigue, no rubber seals. They develop no "end thrust". . . *no reactive forces;* require no expensive anchoring. They are ideal for steam and all kinds of fluids.

Local Barco Field Engineers will be glad to give you full information and recommendations. Call or write today.



Send for this BULLETIN 31

"How To Use Barco Expansion Joints". Complete with piping layout drawings and illustrations. Shows how to cut costs, save time, and do a better job!

PRODUCTS BACKED BY EXPERIENCE — BARCO — FOUNDED 1903

BARCO MANUFACTURING CO.

542M Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Rotary Joints

In Canada: The Holden Co., Ltd., Montreal

Suppliers . . .

quarter in Atlanta, Ga., was formerly district manager in Atlanta for Control Systems Division, Daystrom, Inc.

SPARTON CONTROL SYSTEMS, Sparton Corp., has selected Vene D. Fry Co. representative for a mid-western, four-state area. Located in Mission, Kan., the company will represent Sparton in Kansas, Missouri, Iowa and Nebraska. The firm also represents Layne-Bowler Pump Co.

LUMMUS CO. has named **Dr. Samuel D. Koonce,** Ridgewood, N.J., manager of commercial development. Dr. Koonce joined Lummus after six years as manager, Market Research Department, Commercial Development Division, American Cyanamid Co. Previously, he was with Jefferson Chemical Co.; Distillation Products, Inc.; and Innis Speiden & Co.

Koonce

Dr. Koonce received his B.A. degree from Oberlin College. His M.A. and Ph.D. degrees came from Ohio State University.

GRAYBAR ELECTRIC CO., INC., has made **D. E. Clisbee** manager, Gulf Coast district, with headquarters in Houston. Clisbee replaces **V. R. Young,** who will retire January 1, 1962.

ADAGE, INC., designers and makers of data acquisition and data handling equipment, has named **Malcolm Dresser** manager of marketing services. Dresser comes to Adage from Raytheon.

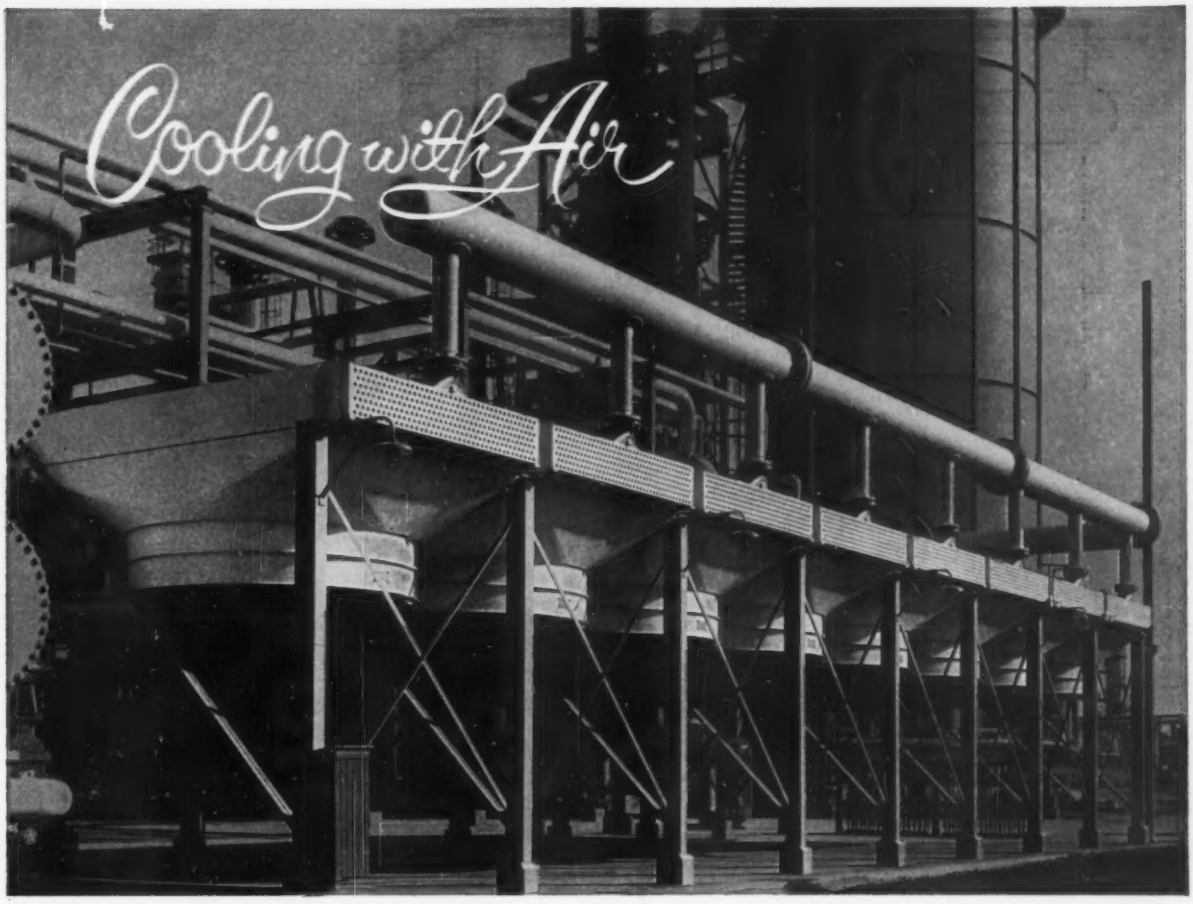
STAUFFER CHEMICAL CO., Consolidated Chemical Industries Division, has promoted **Richard P. Bond** to vice president, sales. He was previously sales manager of the division. Bond joined Stauffer in 1948.

HILLS-McCANNA CO. has named **Vernon M. Barber** sales promotion manager. Barber, formerly district manager in the Gulf Coast area, has been with the company for 10 years.

CORNING GLASS WORKS has named **Donald E. Randall** eastern district salesman. Randall, who joined the company in 1958, will serve the metropolitan New Jersey area.

DE LAVAL SEPARATOR CO. has made **P. N. Paulsen** field service representative for its Pacific Division, Millbrae, Calif. Paulsen was previously with Safeway Stores, Inc.

STERLING ELECTRIC MOTORS, INC., has elected **Alfred E. Grazen** president and



IN THE BAYWAY REFINERY...

of the Esso Standard Division of Humble Oil and Refining Company.

The above pictured installation of HUDSON Solo-aire units obviated costly addition to the existent and comparatively high-maintenance-cost water system.

Over-all economic comparisons of HUDSON Solo-aire cooling versus water cooling almost invariably result in selection of Solo-aire units for much or all process cooling.

In two complete 40,000 barrel seaside refineries constructed abroad, Solo-aire units are used for ALL process cooling services. NO WATER IS USED FOR PROCESS COOLING.

In the United States in a 40,000 barrel refinery built adjacent to an unlimited water supply, 50% of the total dissipated heat is transferred directly to air through Solo-aire units.

Operating results of thousands of HUDSON Solo-aire units installed in oil, gas and chemical plants throughout the free world have established HUDSON leadership in the field of direct cooling with air.

ONLY HUDSON designs and manufactures ALL THREE categories of cooling equipment . . . for cooling solely with air (Solo-aire); for cooling primarily with air but with minimum water to obtain low effluent process stream temperatures (Combin-aire); and water cooling towers. Take advantage of HUDSON'S objective assistance in selecting the integrated cooling system which best balances capital investment and operating cost for the specific process, climatic, and water conditions.

HUDSON

ENGINEERING CORPORATION

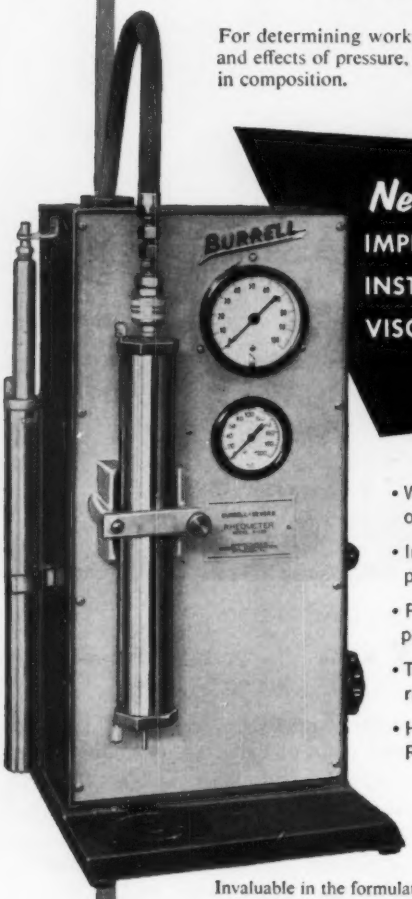
BRAEBURN STATION • HOUSTON, TEXAS

OFFICES: 16033 Ventura Blvd. Encino, California • 122 East 42nd St. New York 17, N. Y. • 199 Bay Street Toronto, Ontario, Canada • 17 Stratton St. Piccadilly London W. 1, England • Corrientes 1115 Buenos Aires, Argen. • Rua Mexico 45 Rio de Janeiro, Brazil

BURRELL "For Scientists Everywhere"

BURRELL-SEVERS
EXTRUSION RHEOMETER
Model A-120

For determining working properties of materials and effects of pressure, time, agitation and changes in composition.



New
IMPROVED AND SIMPLIFIED INSTRUMENT for TODAY'S VISCOSITY PROBLEMS

- Wide viscosity range—one to one million centipoises.
- Independent of the wetting properties of the sample.
- Pressure from zero to 100 pounds per square inch.
- Tests made rapidly. Accurate, reproducible results.
- Has no moving parts. Rugged and easily cleaned.

Invaluable in the formulation, manufacture and end use of printing inks, coatings, adhesives, polymers, food pastes, drilling muds, lubricants, plastisols, paints, paper, putty, cosmetics, soaps, waxes, asphalts, mastics, etc.

BURRELL-SEVERS EXTRUSION RHEOMETER, Model A-120. Complete basic instrument with 3 orifice caps and minor accessories.
Cat. No. 73-851-20 . . . . . 310.00

FILLER TUBE KIT Required for materials that do not flow readily at room temperature. Complete with mounting and cleaning accessories.
Cat. No. 73-851-21 . . . . . 67.50

Stop watch for timing extrusions and balance for weighing also available.

Order by mail—F.O.B. Pittsburgh, Pa. or request additional data.

BURRELL CORPORATION
SCIENTIFIC INSTRUMENTS AND LABORATORY SUPPLIES
2223 Fifth Avenue, Pittsburgh 19, Pa.

Suppliers . . .

general manager. Grazen was an executive vice president of Platecraft of America and a partner in Emco Industries. Sterling Electric Motors is a subsidiary of Hathaway Instruments, Inc., Denver.

PRESSED STEEL TANK CO., Milwaukee, Wis., has elected **W. L. Killen** to the board of directors. Killen is vice president of manufacturing and engineering. He is also executive vice president, Downingtown Iron Works, Inc., a subsidiary of Pressed Steel Tank. A member of the board of directors of Steel Plate Fabricators Association, Killen joined Downingtown Iron Works in 1955. He received his education from Lewis Institute and the University of Chicago.

Killen

THOMPSON RAMO WOOLDRIDGE, INC., TRW Computers Division, has appointed **Ray J. Stanish** general sales manager. He will supervise computer sales throughout the United States and Canada.

GUIBERSON CORP., one of the Dresser Industries, has elected **Gordon G. Guiberson** chairman of the board. In 1937 he was named executive vice president and general manager. He became president in 1951.

CROUSE-HINDS CO. has elected **Raymond W. Cummings** vice president, finance. Cummings joined Crouse-Hinds in June 1956 as controller. He was made secretary in April 1958 and treasurer in October 1958. He continues to hold the two latter positions.

CHICAGO PNEUMATIC TOOL CO. has appointed **Russell B. Miller** general sales manager. To headquarter at the company's New York general offices, Miller has been with Chicago Pneumatic for more than 25 years.

BRIDGEPORT BRASS CO., division of National Distillers and Chemical Corp., has named **John M. Dumser** assistant to the president. Dumser has been with Wolverine Tube Division, Calumet and Hecla Corp., for the past nine years as director of marketing.

UNITED STATES STEEL CORP. has appointed **J. M. Haynes** product manager, Wilson-Snyder Process Pumps Division. Haynes will headquarter at Dallas, Texas.

DE LAVAL SEPARATOR CO. AND DE LAVAL STEAM TURBINE CO. have named **Elbert G. Bellows** assistant to their presidents. Bellows will headquarter in De Laval's New York offices. He has been with

the conduit that saved 10%

What happened at Strick Trailer Company's new plant in Philadelphia when almost two miles of Alcoa® aluminum electrical rigid conduit was installed?

The cost was approximately 10% less than to do the same job in steel.

The reason? Fewer man-hours are required to install aluminum conduit. Based on figures published by NECA in 1959, installation of 100 feet of 4-inch aluminum conduit under a 12-foot ceiling takes 17.5 man-hours; the same installation in steel requires 30 man-hours. In this case, it takes 71% more labor units to install steel.

Aluminum weighs 66% less—pounds that never have to be loaded, unloaded, hefted and suspended. And Alcoa aluminum conduit bends easily, with little or no springback. It is easy to cut and thread; in fact, some studies show labor savings as high as 50% for cutting threads.

Since aluminum is inherently resistant to corrosion, service life is often longer, too, particularly in corrosive environments. No protective coating needed to prevent corrosion. No routine painting required to preserve its usefulness.

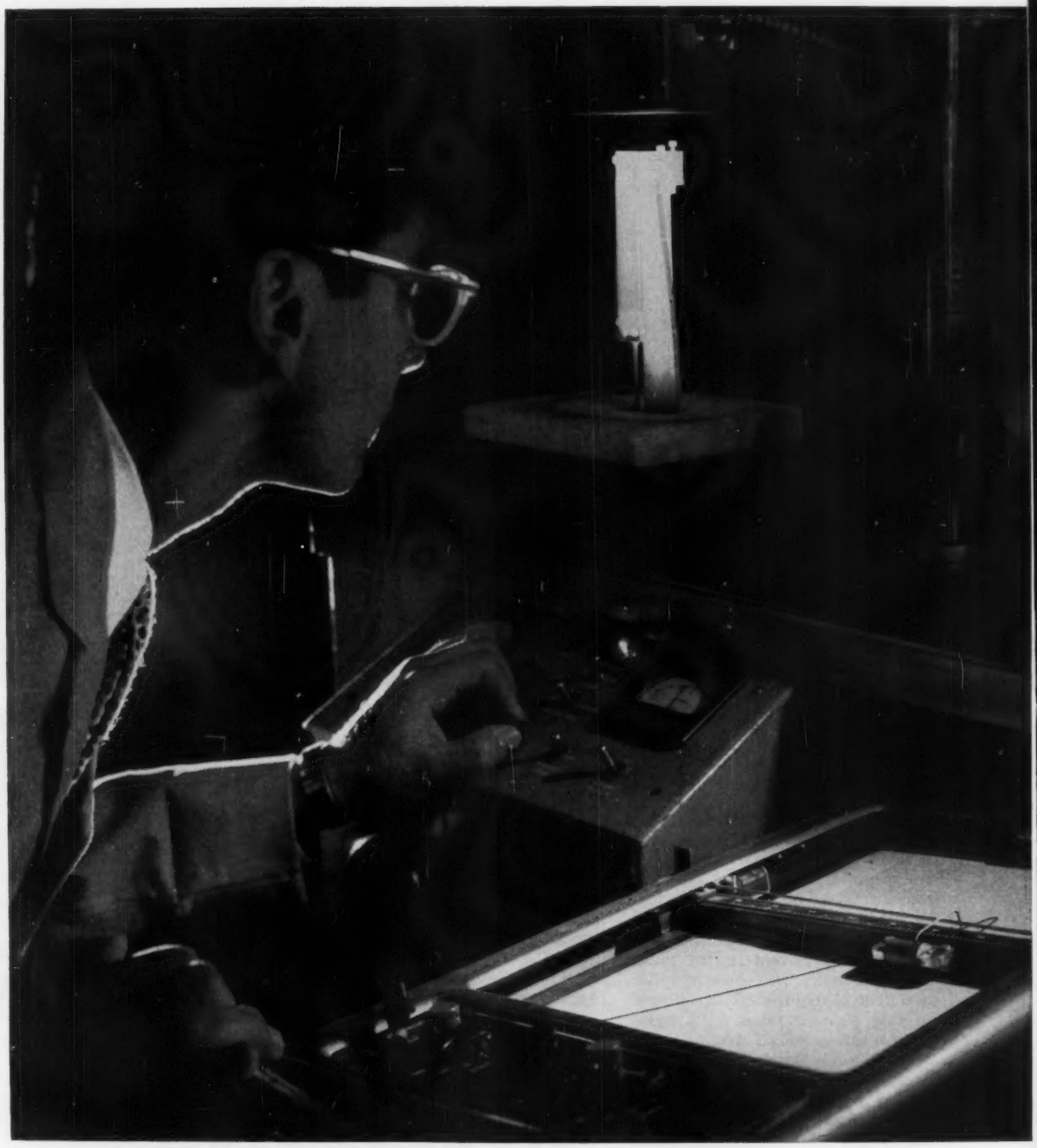
How much can you save? The actual dollars depend, naturally, on the nature of your installation. For the complete story, contact your Rome-Alcoa representative. Or write to Rome Cable Division of Alcoa, Dept.19,111, Rome, N. Y.

SAVED 10% by installing Alcoa aluminum conduit instead of steel at Strick Trailer Company's new Philadelphia plant.

Conforms to ASA C80.5-1960—Rigid Aluminum Conduit and Federal Specification WW-C-540a

ALCOA
ROME CABLE
DIVISION

How controlled stress makes Glasteel™



For more data on advertised products, use cards, last page.

strong

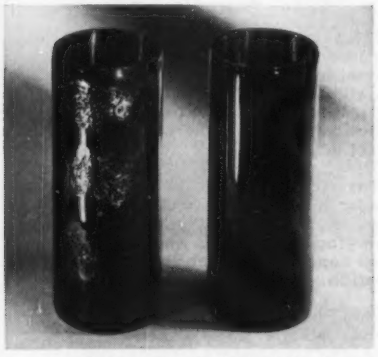
If you're concerned about the possibility of a glassed-steel vessel crazing from thermal shock . . . if you've had doubts about its ability to stand up to mechanical shock . . . read on to learn how stress data recorded by the research apparatus at left are translated into structural strengths.

The glowing sample of Pfaudler Glasteel has just undergone a stress-strain analysis. Differential expansion between glass and steel was recorded during controlled heating. Reason? To determine how much compressive stress is present in the glass.

This stress, called a compressive cushion, is *designed into* Glasteel to permit it to bend, stretch, breathe — absorb thermal shock.

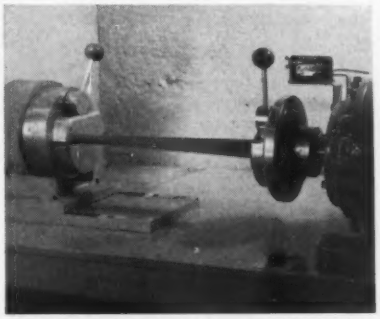
And the precise stress-strain tests which we employ permit us to predict and control the amount of compressive cushion in Glasteel over the complete operating-temperature range of a fabricated vessel.

260°△T. Controlled stress in Glasteel gives you the thermal protection of a 260° differential between product and jacket media at an operating temperature of 250° in all vessels through 2000 gallons. (We consider this a safe recommendation because it contains a very generous factor of three, based on carefully controlled laboratory experiments.)



In spite of an unusually high 455° thermal shock, no damage was done to the lab sample of Glasteel pipe at right, glassed with today's standard Pfaudler glass. Pipe at left was glassed with our previous standard.

Locked together. Glasteel as a material of construction is strong in other ways, too. The bond between the glass and steel, created by chemical action during firing, locks the components firmly together. Like this:



Even though the Glasteel bar has been twisted to the elastic limit of the steel, the glass-to-steel bond and the glass itself remain intact.

Bolt torque test. So strong is Glasteel that in a bolt torque torture test on a glassed flange, the steel portion of the flange yielded before the glass.

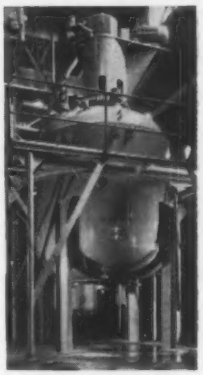
More tests. In point impact tests, Glasteel is 2½ times more resistant than safety plate glass. Under conditions of erosion-corrosion, it is more abrasion resistant than most metals.

On both the Knoop and other hardness scales, the glass component in Glasteel is harder than the common metals.

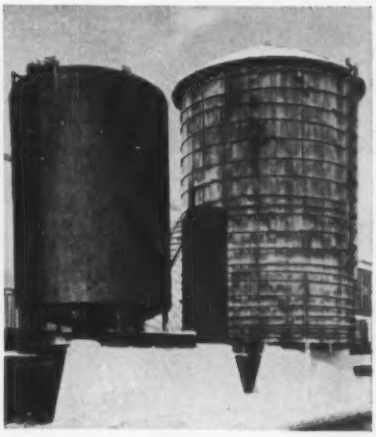
Summing up. When you specify Pfaudler Glasteel process equipment, you want excellent acid-alkali resistance. You get it. In addition, you get a compressive cushion to stand up to thermal and mechanical shock, a virtually indestructible bond between glass and steel, a hard, nonporous product-contact surface. And the assurance that our specifications are the accumulative result of extensive lab tests and many years of field experience.

Bulletin 985 is our fact book on Glasteel. For your copy, please write to the address indicated.

FLUIDICS AT WORK



Big Glasteel reactors are increasingly a common sight on our production line. Like this 6000-gallon model with its 120″ I.D. and 98″ straight-side. The Pfaudler® agitator drive is rated here at 75 HP. It's our TW type, which can handle up to 200 HP. You can specify Glasteel reactors to 17,000 gallons and storage tanks to 35,000 gallons. Let us consult with you on your requirements for big process equipment.



Glasteel for storage at elevated temperatures. We've just upped the temperature limit for Glasteel storage tanks in sizes up to 10,000 gallons. It's now 180°. Thus, such tanks are a better investment than ever for storing corrosive, sticky or ultra-pure liquids. Example: Tank at left above holds 5000 gallons of hot (150° to 180°) water for a laundry, has been in continuous use for 4 years. Wooden tank at right is for cold-water supply.

Glasteel pipe, valves and fittings are detailed in Bulletin 987. In its 16 pages you'll find the "specs" needed when you plan transfer of corrosive materials to and from process equipment. Ask for a copy.

Address all your inquiries to: Pfaudler Division, Dept. PR-111, Rochester 3, N. Y. In Canada, contact Pfaudler Permutit Canada Ltd., Toronto.

PFAUDLER PERMUTIT INC.

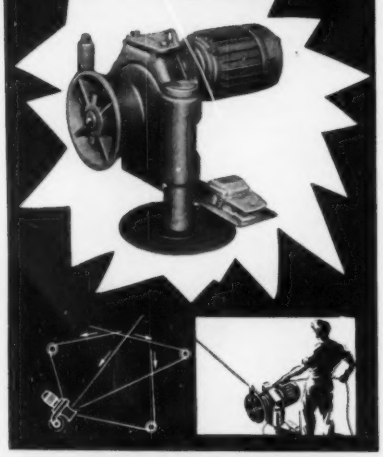
Specialists in FLUIDICS . . . the science of fluid processes

For more data on advertised products, use cards, last page.

SADI
VALVE OPERATORS
Adaptable to NEW and EXISTING VALVES

THOUSANDS of operators in service throughout the world, typical examples of SADI power transmission equipment quality

SADI
HAULAGE CAPSTANS
TRANSPORTABLE
ECONOMICAL
DEPENDABLE



SADI S.P.R.L.
4, RUE CARBURANTS
BRUSSELS 19 — BELGIUM

Suppliers . . .

Maxson Electronics Corp. for the past eight years.

KOEHRING CO. has elected **Orville R. Mertz** to the board of directors. Mertz joined Koehring in 1953 as controller and was promoted to vice president of finance in 1955.

VOKES, LTD., a British designer and manufacturer of filtration equipment, has concluded an agreement with Chain Belt Co., Milwaukee, Wis., to make a complete line of process equipment in Britain and certain European areas.

NORIT SALES CO. OF CANADA has made **Peter J. Frekenhorst** manager. **B. Vriezen,** former manager, has been transferred to the firm's Amsterdam, The Netherlands, office. The company's Canadian office is in Toronto.

PERKIN-ELMER CORP. has named **John C. Stick, Jr.,** director of research, Instrument Division. Stick, who succeeds **John G. Atwood,** joined Perkin-Elmer in December 1960 as special assistant to the general manager, Instrument Division.

BABCOCK & WILCOX CO. has moved its Tubular Products Division Houston sales office to 3015 Richmond Ave. Office mailing address is P. O. Box 25127, Houston 6, Texas. **W. C. Mohrman** is Houston district sales manager.

COOPER-BESSEMER CORP. has made **Robert Cizik** executive assistant, corporate development. Cizik was a financial analyst, Treasurer's Department, Standard Oil Co. (New Jersey).

SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION, Beckman Instruments, Inc., has appointed **John Schafer** sales engineer. Schafer will represent the division in North Chicago, Minnesota, Wisconsin, North Dakota and Michigan.

SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION has appointed **Jack L. Mayfield** sales engineer. Mayfield, who will be based in Richmond, Calif., will handle sales in the Northern California-Nevada area.

AIR REDUCTION SALES CO. has named **C. J. Langley** manager, Philadelphia district. Langley, who succeeds **R. H. Merriman,** joined Airco in 1946 in the General Technical Department, New York.

ARMOUR INDUSTRIAL CHEMICAL CO. has named **R. H. Warner** western regional sales supervisor. Warner, who will headquarter in Los Angeles, joined Armour in 1954 as a special assistant for industrial oils.

PACIFIC PUMPS, INC., a division of Dresser Industries, Inc., has appointed G & J Weir, Ltd., Glasgow, Scotland, a manufacturer and marketer of centrifugal

316 STAINLESS STEEL
Welded Bourdon Tube and Pressure Connection

A NEW ADDITION to
MERCOID
PRESSURE CONTROLS
Series D-41, 243, 541

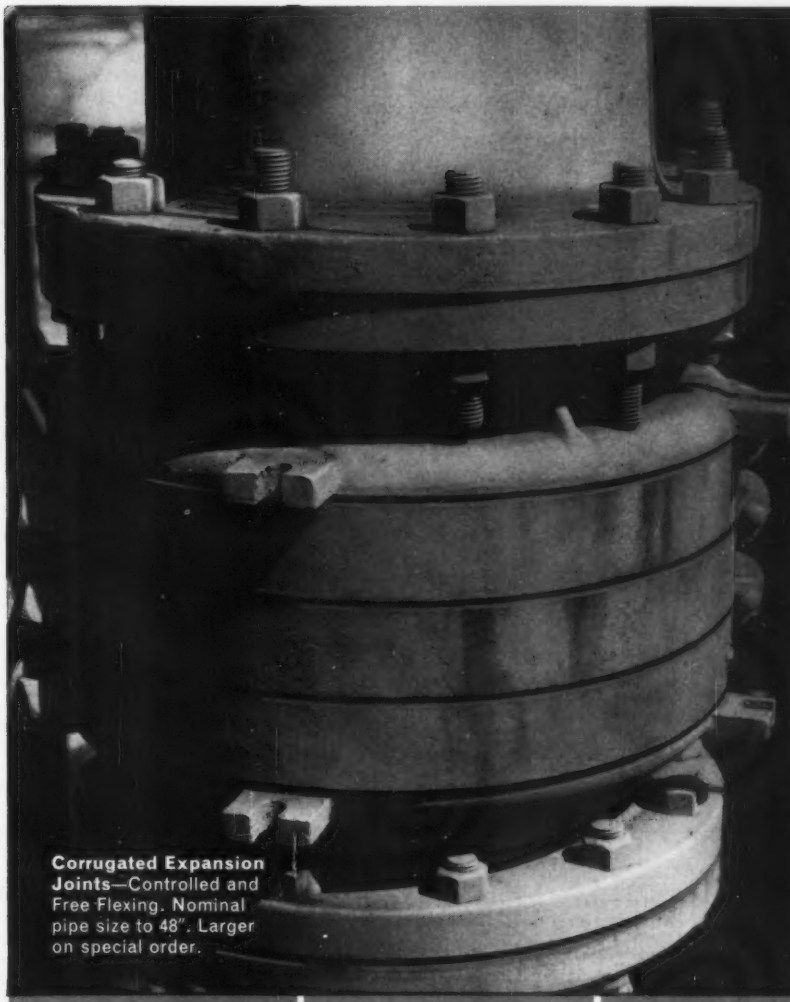
316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.— with varying differentials and electrical capacity to meet your application.

Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

WRITE FOR BULLETIN 019

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.



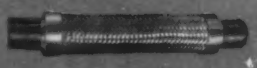
Corrugated Expansion Joints—Controlled and Free Flexing. Nominal pipe size to 48". Larger on special order.

ONE SOURCE... ONE RESPONSIBILITY...

FIVE SOLUTIONS TO PIPE MOVEMENT PROBLEMS

Flexonics . . . and only Flexonics offers you one responsible source to insure sound piping installations where thermal expansion and contraction, vibration, and other forms of pipe motion exist. Mail the coupon for your FREE copy of the new Flexonics Engineering Guide . . . 42 pages of pipe motion calculations, tables, anchoring and guiding data.

Expansion Compensators—Low and high pressure models. Available in steel, all stainless steel, and bronze.



Flexible Connectors—Bronze and hot dipped galvanized steel. Pipe size to 14". Nipple, weld, or flange ends.

Pipe Alignment Guides—All steel construction for pipe size ¾ to 24". Moves axially in segmented steel cylinder.

Roller Pipe Insulating Supports—All steel, formed saddle. Pipe sizes ½" to 14". Larger sizes on special order.

EJ-280

Flexonics

DIVISION OF CALUMET & HECLA, INC.
378 East Devon Avenue • Bartlett, Illinois

FLEXIBLE METAL and SYNTHETIC HOSE EXPANSION JOINTS
BELLOWS • SPECIAL TUBULAR ASSEMBLIES

In CANADA
FLEXONICS CORPORATION OF CANADA, LTD.
BRAMPTON, ONTARIO

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Flexonics
371 E. Devon Ave.
Bartlett, Ill.

Please send me Flexonics Engineering Guides and other information in the areas that I have checked:

☐ Flexonics Expansion Joints
☐ Pipe Alignment Guides & Supports
☐ Flexonics Expansion Compensators
☐ Flexonics Flexible Connectors

For more data on advertised products, use cards, last page.

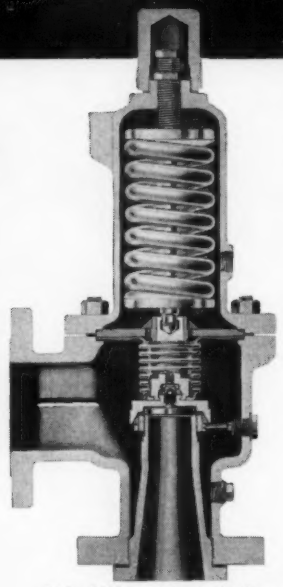
value...

the reason FARRIS OUTSELLS all others

Farris Process Safety-Relief valves have unique design features which provide product serviceability and dependability unmatched by *any* competitive valve. True value is "built into" Farris valves.

- **2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.**
- **High thermal expansion of sleeve guide and low thermal expansion of hardened stem retainer stops binding at high temperatures.**
- **Hardened stainless steel optically lapped disc . . . self aligning for maximum tightness.**
- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
- **Industry's most complete line. Available in cast iron, steel and special materials. Sizes ½" to 8". Pressures to 10,000 psig. Temperatures to 900°F. Enclosed or exposed springs. Plain, open lever or packed lever construction.**

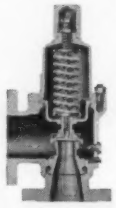
All Farris Nozzle Valves Conform To ASME Power Boiler Code, Section 1, and The ASME Unfired Pressure Vessel Code, Section 8.



Series 2600 . . Balan-Seal bellows. 150 to 6000 psig. Also without bellows.

Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.

Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.



Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.

Write for **FREE** Catalog **FE-118**

GET FULL VALUE: Replace With Farris... Complete Interchangeability With Standardized Face To Face Dimensions.

ENGINEERING CORP.

536 COMMERCIAL AVENUE
PALISADES PARK, NEW JERSEY

AFFILIATES: Farris Combustion Controls Corp. • Farris Flexible Valve Corp. • Farris Universal Machine Corp. Farris Industries Canada Ltd. • Farris Engineering Ltd., London, England

Suppliers . . .

pump products for the petroleum, petrochemical and chemical industries.

GENERAL BLOWER CO. has named **Richard Friese** sales representative in the Chicago area. Friese will handle centrifugal fans, turbo blowers and heat fans through William W. Meyer & Sons, Inc., Skokie, Ill.

CONTINENTAL-EMSCO CO. has opened a pump shop at Grayville, Ill., as a supply center for rods, couplings and lease maintenance supplies. **Francis Krutsinger** has been named shop manager.

JONES & LAUGHLIN SUPPLY DIVISION has appointed **Wendell Cooper** supervisor, data processing section. Cooper joined J & L in 1946.

HILLS-McCANNA CO. has named **Robert E. Lindquist** industrial sales manager. Lindquist, formerly eastern regional sales manager in New York City, has been with the company for 10 years.

HEAD WRIGHTSON EXPORT CO., LTD., has elected **E. J. Robinson** a director, **R. F. N. Otway** has joined the company as manager, Europe. Head Wrightson Export handles trade in overseas markets for Head Wrightson companies.

THE OHIO INJECTOR CO. has completed arrangements to make valves in Mexico. The venture is part of Ohio's market expansion in Latin America.

BADGER MANUFACTURING CO. has named **Charles R. Eisenstein** district manager, sales and engineering, Expansion Joint Department. Eisenstein will direct sales and engineering in the New York, Long Island and Northern New Jersey areas.

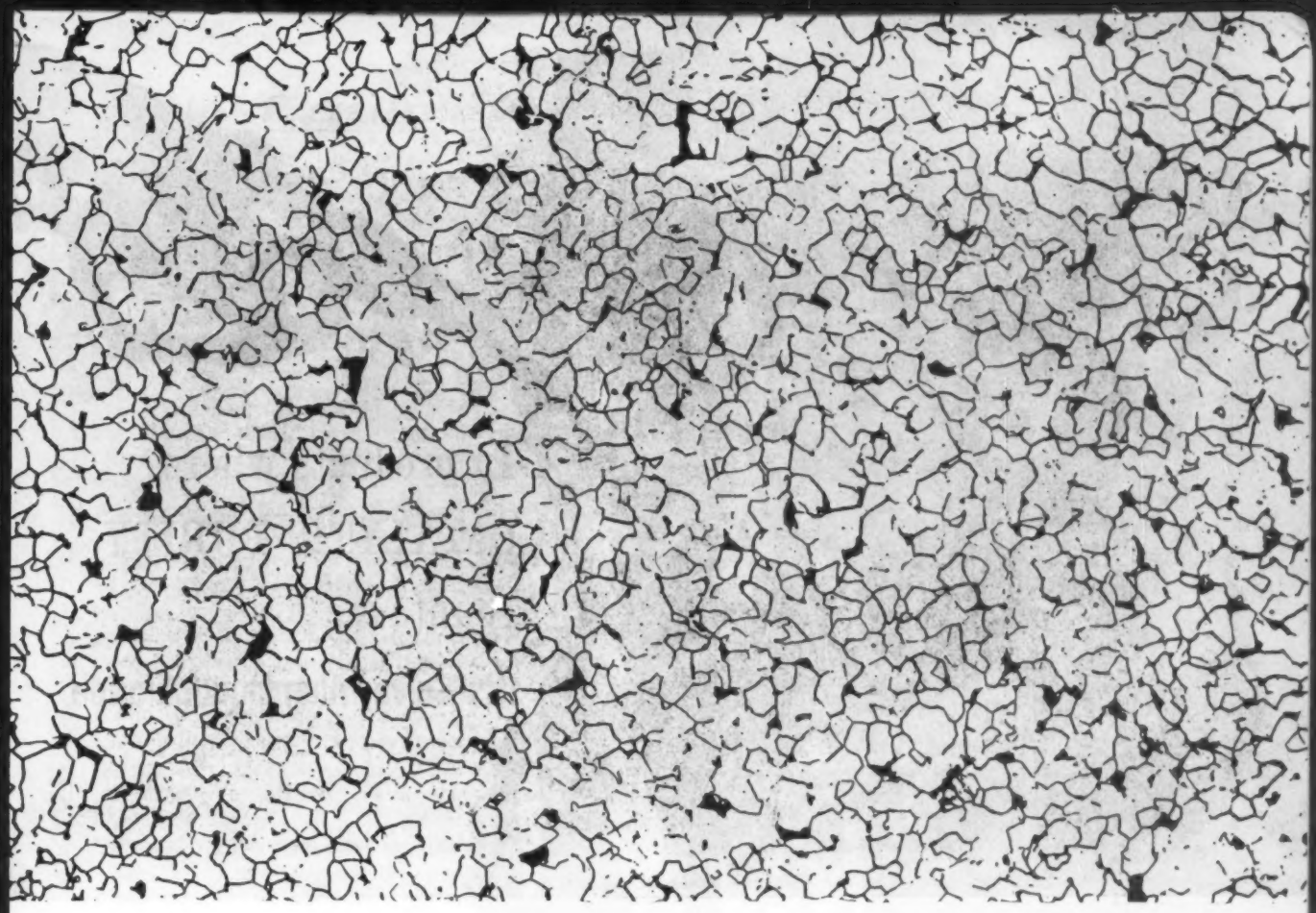
MILTON ROY CO. has elected **John Procopi** vice president of international operations. Procopi will handle marketing in all areas outside the United States and its possessions with emphasis on Western Europe. He has been with Milton Roy for eight years.

Reprint on VALVES

The 16-page special report on "Valves—How to Select Them for the Right Job at the Lowest Cost" which was featured in HP-PR's October issue is available in reprint form.

Send 50 cents with order to:

Reprint Department
Gulf Publishing Co.,
Box 2608, Houston 1, Texas



Can you spot the weld in this picture?

If you can't see a weld in this magnified photo of a steel tube, there's nothing wrong with your eyesight. Even though the weld section has been magnified 100 times, you can't see the weld because it's perfect—but you could spot a flaw immediately. That's why we use metallographic examination like this to check Electric Resistance Welded Pressure Tubes. In addition to checking the weld, we also examine the grain structure of the steel tube to make sure it's consistent.

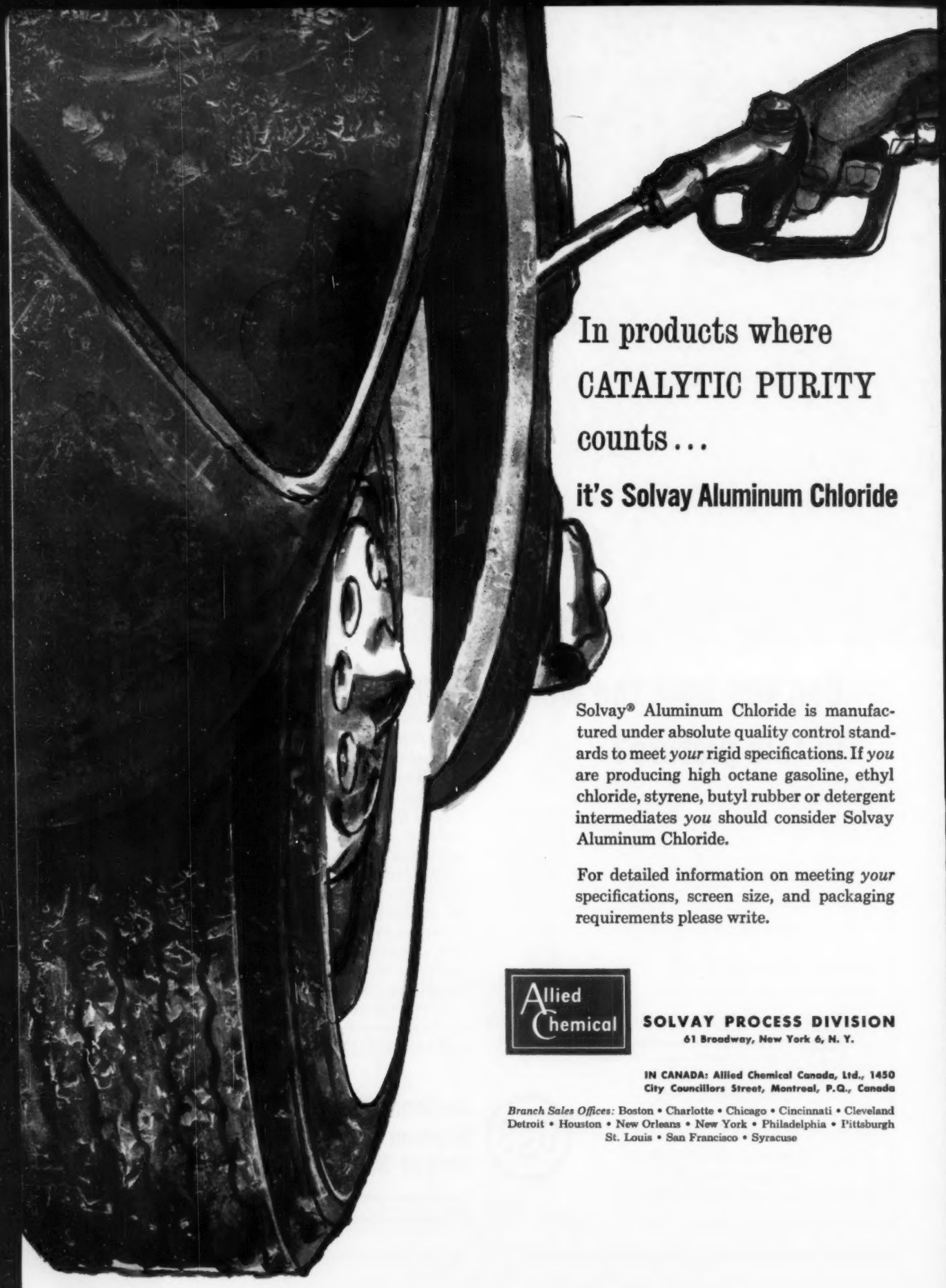
USS National Welded Pressure Tubes *must* be flawless to meet the critical requirements of refinery applications. To be absolutely sure the tube is as perfect as can be made, we also use non-destructive ultrasonic testing, hydrostatic testing and thorough visual inspection techniques. You can depend on USS National Welded Pressure Tubes —order from your National Tube Distributor who stocks them in the following sizes: ½″ O.D. x .035″ wall to 5½″ O.D. x .250″ wall.

USS and National are registered trademarks

This mark tells you a product is made of modern, dependable Steel.

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York



In products where CATALYTIC PURITY counts...

it's Solvay Aluminum Chloride

Solvay® Aluminum Chloride is manufactured under absolute quality control standards to meet *your* rigid specifications. If *you* are producing high octane gasoline, ethyl chloride, styrene, butyl rubber or detergent intermediates *you* should consider Solvay Aluminum Chloride.

For detailed information on meeting *your* specifications, screen size, and packaging requirements please write.

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New Equipment & Literature...

as selected by Frank L. Evans, Jr., Mechanical Engineering Editor

Easy Turning Plug Valve Is Lubricated for Life

A new concept in tapered plug valve design uses a high lubricity plastic coating that substantially reduces turning and provides lifetime, maintenance-free operation.

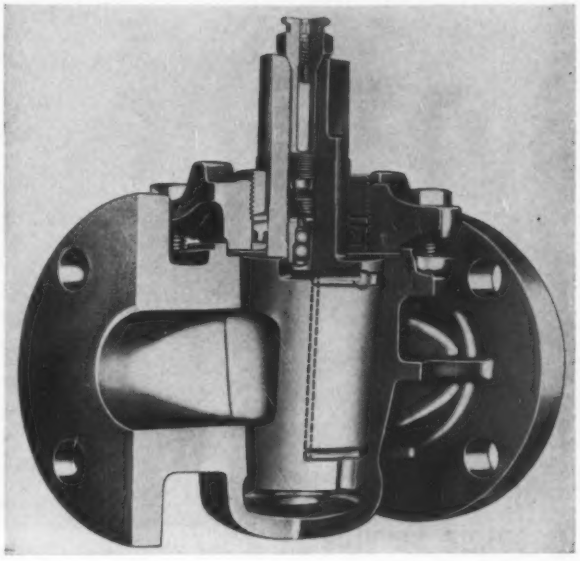
Major design feature of Permaturn valves is a high lubricity plug coating of the order of 0.0005-inch applied to tapered surfaces. For low pressure valves, pressures up to 1,000 psi, the coating is Teflon. For high pressure services, up to 10,000 psi, the valves are coated with phosphate-molybdenum disulfide. Both coatings are permanently bonded to metal surfaces of the tapered plugs under closely controlled operations.

Metal-to-metal contact is eliminated, thus making it virtually impossible for the valve to stick or freeze in service.

Besides high lubricity coatings, two other features have been incorporated in the design which materially reduce maintenance on most applications.

One is a fixed adjustment assembly used on low pressure valves to maintain a constant tight seal after repeated openings and closings and to facilitate uniform turning ease. The assembly is pre-set at the factory and requires no further adjustment or attention in the field for the valve's life.

The second feature is designed for valves on extreme high pressure services. This consists of a threadless stem that reduces the high operating torques of conventional high pressure valves. Rockwell Mfg. Co.



Circle E1 green card, last page

Vapor Pressure Apparatus Ten Times More Accurate

A new model micro-vapor-pressure apparatus, MVP1300, handles high vapor pressures, has digital read-out and incorporates several other design improvements.

Result: It is much easier to operate and maintain; it will handle any kind of sample from crude oils to high-vapor-pressure aviation fuels—and the higher-boiling viscous samples above the gasoline and jet-fuel ranges; it has a digital read-out computer; the possibility of glass breakage is eliminated—as is handling of mercury; precision is now 10 times greater than that of the Reid method.

A rugged stainless-steel cell instead of a water-jacketed glass bulb, houses the vapor pressure chamber. The cell is mounted on the stainless-steel top of the instrument cabinet; all its critical parts are thermostated at 100° F by the water jacket.

The sampling system now utilizes a small stainless-steel bomb that fills a sample-holding chamber in the cell. This eliminates the glass pipet, permits handling of samples with very high vapor pressures.

The 0.3-ml volume of the sample stem gives a 4:1 vapor/liquid ratio in the 1.2-ml chamber. Hence, direct correlation with Reid.

Extremely precise measurement of pressure in the chamber is made by the special manometric gage, a new

Fast, intermittent trap action . . .

Nicholson weight-operated traps for gas, air, steam and gasoline service

This sectional illustration describes the fast, intermittent action of Nicholson weight-operated traps for pressures up to 1500 lbs. But don't let that float fool you. This trap is float-actuated, not float-operated as are other float-type traps. Here's how this exclusive Nicholson feature works.

When water enters the trap the float rises, eventually *actuating* the weight latch to release the counterweight, which then falls, lifting the discharge valve wide open . . . *instantaneously*. A link latch holds the valve open until discharging water lowers the float, *actuating* the rising counterweight to re-engage the weight latch. The discharge valve is then released by the link latch and closes *instantaneously*.

This rapid, intermittent opening and closing action is a feature you'll find *only* in Nicholson weight-operated traps, including models JR for pressures to 250 lbs., WO and B to 650 lbs., and C to 1500 lbs. Mail coupon for Catalog 500.

W. H. NICHOLSON and CO., 12 Oregon St., Wilkes-Barre, Pa.

Please send Catalog 500 describing Nicholson weight-operated traps for saturated or superheated steam, compressed air and gasoline, oil and gas service.

Name.....

Company.....

Title.....

Street.....

City..... Zone..... State.....

W. H. NICHOLSON and COMPANY
12 Oregon Street • Wilkes-Barre, Pa.

Our 80th Year

New Equipment . . .

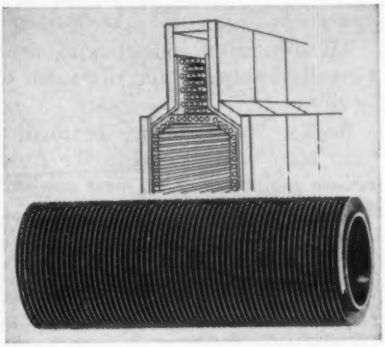
type of U-tube mercury manometer.

The mercury level in the gage tube attached to the chamber is kept constant by a mercury displacement piston (rather than a leveling bulb). Hence, vapor volume of the chamber does not vary during measurement. Fisher Scientific Co.

Circle E2 green card, last page

More Surface Area in New Designed Furnace Tubes

Large diameter K-Fin tubing is designed specially for use in the convection sections of furnaces heating petrochemicals or hydrocarbons for processing; waste heat boilers; for tank heating and other fired and unfired applications. These tubes provide 10 times or more outside surface



area per foot of length than plain bare pipe or tubing, increasing the capacity of the furnace, the efficiency of the furnace, or both.

The helical fins are wrapped tightly into grooves plowed on the outside of the tube or pipe. The metal displaced by the grooves is then forced tightly against the sides of the fins by a patented, proven process to form a tight metal-to-metal bond. These finned tubes and pipes are suitable for any service for which bare pipe or tubing is satisfactory. They are available with carbon steel, stainless or alloy fins, on carbon steel, stainless or alloy pipe or tubing 1 to 6-inch diameter pipes or tubes; with from two to eight fins to an inch, to meet a wide range of operating requirements. Technical data available. The Griscom-Russell Co.

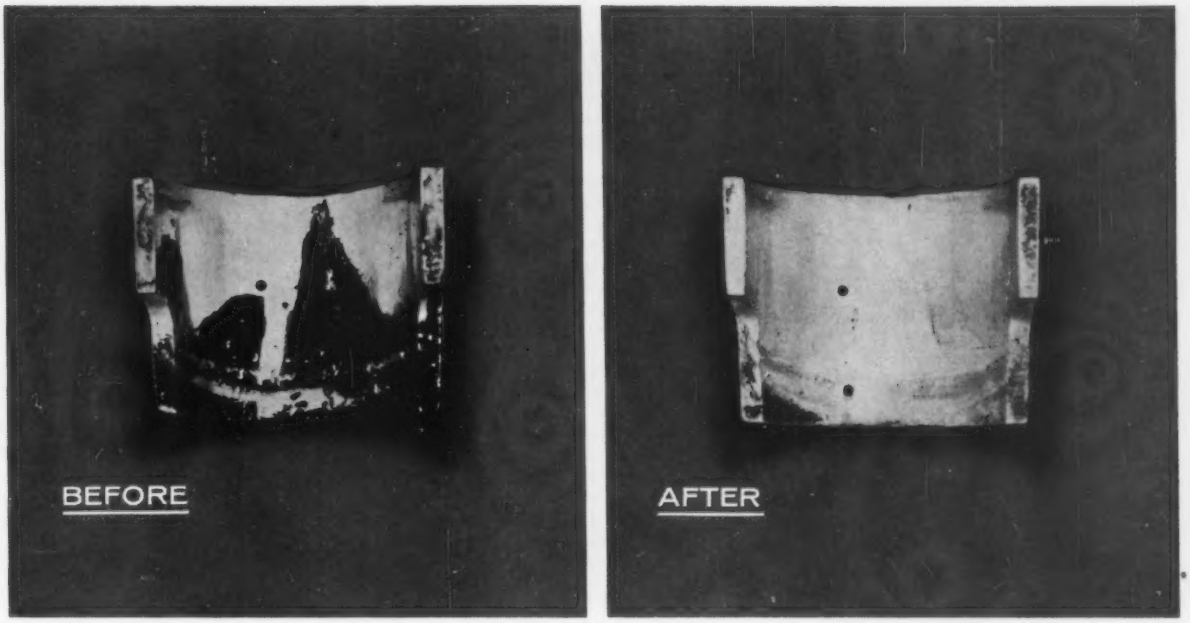
Circle E3 green card, last page

Compact Pipe Fittings Cut System Piping Costs

A completely new line of welding fittings called the compact line, has

Du Pont *Petroleum Chemicals* News

Number 110 in a series of bulletins for the Petroleum Industry OCTOBER • NOVEMBER 1961



Du Pont's multifunctional additive, DMA-4, cleans carburetors and keeps them clean

Carburetor detergency is a striking example of the performance values you can add to gasoline with Du Pont DMA-4.

The carburetor throat liner you see above illustrates how this additive cleans up power-robbing deposits.

On the left, the liner is coated with residue after exposure to an untreated premium gasoline, under severe test conditions. On the right is the same liner after only two hours additional operation under normal operating conditions using the same gasoline treated with DMA-4 at a concentration of 10 pounds per thousand barrels.

Results of other tests have demonstrated that six pounds of DMA-4 per 1,000 barrels of gasoline will prevent deposit accumulations even under the severe conditions utilized to develop the "before" build-up shown above.

The "clean – keep clean" detergency action of DMA-4 is, however, only one of the performance values offered by this Du Pont additive. DMA-4 also offers:

- *Anti-stalling properties.* DMA-4 sets up a protective film that makes throttle plates and other internal surfaces water repellent, thus preventing stalling due to ice formation on cool, damp days.
- *Rust prevention.* The protective film also protects metal surfaces (engine parts as well as pipelines and storage tanks) from corrosion.
- *Phosphorus credit.* DMA-4 contains phosphorus compounds of the type helpful in suppressing surface ignition and spark plug fouling caused by combustion chamber deposits. The concentration of other phosphorus additives can, therefore, be reduced proportionately to obtain minimum treating costs.

Descriptive Bulletin Available

A product bulletin describing DMA-4 is available. To obtain your copy, and to find out how DMA-4 may add new performance and sales values to your gasolines, contact your Du Pont Petroleum Chemicals Division representative.

How you gonna keep 'em . . . ?

Keeping your "down on the farm" petroleum customers may depend on a lot of variables.

To help you understand the

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER ▶

Du Pont *Petroleum Chemicals* News

(continued–How you gonna keep 'em . . .)
farmer-buyer of gasoline, we have extracted facts pertaining to farmers and their buying habits from our nationwide "Profile of the Motorist" survey.

These data are available to you in a new break-out report entitled "The Farmer".

Contents of this report include such subjects as credit card vs. charge accounts, loyalty to a single station, and the farmer's experiences with trading stamps and price wars.

Copies of "The Farmer" summary are available to interested parties in the oil industry as a Du Pont service. For your copy, get in touch with your Du Pont Petroleum Chemicals representative.

SEATTLE DISTRICT MANAGER

ROBERT E. HOLETON is District Manager of our Seattle office.

Under the watchful eye of an uncle who "insisted that I must learn something about everything," Bob spent his early years at summer jobs that ranged from helping to train racehorses to printing, deep-sea diving and sand-hogging.

In 1933, he came to Du Pont after completing premedical requirements. Bob continued his schooling while working, finishing as an organic chemist at Temple University in 1943. He started as a technician in our Eastern Laboratory, was progressively promoted to higher responsibilities in eight Du Pont Laboratories, and joined the Petroleum Chemicals Division as a sales service representative in 1949. He has been Seattle District Manager for seven years.

His technical background and research experience have served Bob well in helping petroleum refiners in the Northwest through his knowledge of antiknocks and other petroleum additives.

Bob and his wife, Rachel, live in Bellevue, Washington. They have five children.

The show about the road is now on the road

Every road in America leads to adventure.

This, in seven words, is the theme behind one of the oil industry's latest travel development tools – Du Pont's half-hour color movie, "Highway Holiday."

"Highway Holiday" is a 16mm version of the Cinemascope feature "Down the Road," which is now being distributed to theaters across the nation by 20th Century-Fox. "Holiday" is designed for non-paying showings to any interested group. Both films are part of Du Pont's marketing services to the oil industry.

"Highway Holiday" takes the audience to all corners of the American continent – from the sweeping highway across the Painted Desert to a historic old village in New England, from the gleaming sands of Daytona to the majestic mountains of Canada, from Quebec to Mexico.

All this travel has a meaning. "Highway Holiday" will encourage a greater appreciation of the heritage and beauties of America, and stimulate motorists' interest in seeing them first-

hand through the convenience and comfort of the family car.

Prints available

You can obtain prints of "Highway Holiday" for showing to clubs and other groups, or for local television use. The film is intended to provide you, as a marketer of gasoline and other oil products, with a *broad* "expand-the-demand" promotion, as a backdrop for your own travel development activities.

For further information, contact your Du Pont Petroleum Chemicals representative.

Railroad learns what happens when it stops using FOA-2

Not long ago, a leading railroad tried an interesting experiment:

They had been using Du Pont FOA-2 to keep diesel locomotives free from filter plugging and other potential fuel problems. At one point, however, they felt that the sludge problem wasn't severe enough to justify continued use of FOA-2 in certain fuels. They decided to find out.

Shortly after the test started, several cases of fuel incompatibility were reported for the first time; filter plugging increased; and it was quickly found that the cost to replace the filters was more than the cost of the FOA-2 they had previously used.

Today, this railroad is once more using FOA-2 to reduce sludging and keep filters clear. Costs and maintenance worries are once more back in line.

TELEPHONE NUMBERS FOR SALES OFFICES

	Area Code*	Telephone No.
Chicago 3, Illinois–		
8 S. Michigan Ave.	312	RA 6-8630
Houston 2, Texas–		
702 Bank of Commerce Bldg	713	CA 5-1151
Los Angeles 17, California–		
612 S. Flower St.	213	MA 4-1354
New York 20, New York–		
45 Rockefeller Plaza	212	CO 5-2342
Philadelphia 2, Pennsylvania–		
3 Penn Center Plaza	215	LO 8-3531
Pittsburgh 22, Pennsylvania–		
One Gateway Center	412	AT 1-2933
San Francisco 4, California–		
111 Sutter St.	415	EX 2-1934
Seattle 3, Washington–		
4003 Aurora Avenue, North	206	ME 2-6977
Tulsa 19, Oklahoma–		
1811 South Baltimore Ave.	918	LU 3-8581

	Area Code*	Telephone No.
Canada		
Toronto 12, Ontario–		
Du Pont of Canada, Limited Petroleum Chemicals, 85 Eglinton Avenue, East	416	HU 1-6461
Other Countries		
Wilmington 98, Delaware–		
Organic Chemicals Department Export, 7451 Nemours Building Petroleum Chemicals Division	302	PR 4-5009

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Better things for better living
. . . through Chemistry

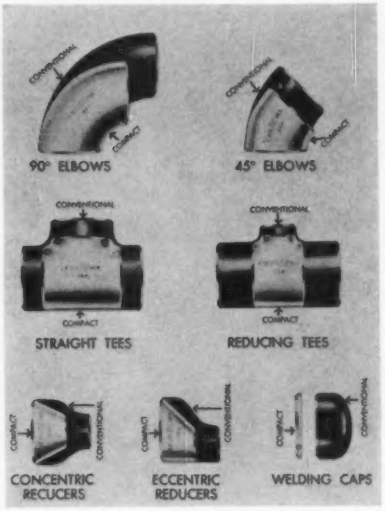
Du Pont Antiknocks and other Petroleum Additives

OVER

ADVERTISEMENT–Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

Printed in U.S.A.

New Equipment . . .



been developed to reduce cost in welded heating and cooling system piping and similar moderate and low pressure welded lines.

The line has been compacted to the sizes and types of fittings usually required for heating-cooling piping—90 and 45-degree elbows, straight and reducing tees, concentric and eccentric reducers and caps in sizes 2, 2½, 3, 4, 5 and 6 inches; reducing tees and reducers with reductions in the intermediate ips down to one-half of run or large-end size. Ends are accurately sized in thicknesses to match corresponding sizes, and thicknesses, of schedule 40 pipe. All are seamless and made only in Grade B carbon steel.

The fittings are arbitrarily designated as Class 125 (WOG rating, 175 psig; saturated steam rating, 125 psig.) However, cycling and bursting tests have shown this rating to be conservative.

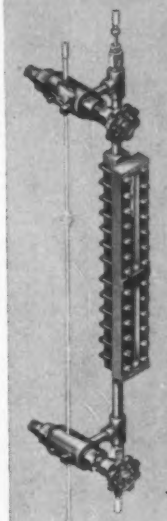
All facts, including sizes, weights and dimensions, are covered in bulletin 619 "A New Concept in Welding Fittings." Taylor Forge & Pipe Works.

Circle E4 green card, last page

Shop Manifolded Exchanger Cuts Process Revamp Costs

Completely preassembled and pretested double pipe hairpin heat exchangers are now available bolted together and manifolded to the customer's specifications. Furthermore, all units are given hydrostatic tests to insure satisfactory on-the-job op-

When you need
HEATED GAGES and VALVES



select from a complete line . . . Jerguson offers you a model for every need

Jerguson Heated Gages and Valves are built to meet the special conditions present when working with liquids which must be kept at higher than ambient temperatures . . . for process reasons or to hasten the speed of response to level changes. They also have wide application to prevent breakage through freezing.

Select from a complete line

- Reflex or transparent gages
- Union or non-union valves
- External or internal heating
- Steam or electric heating
- Materials meet or exceed AISI, ASTM and/or API-ASME requirements

New Electric Heating

Electrically heated gages have a completely new heating system with greatly improved efficiency. For use where steam is not available. Offered in External Tube Models only.

Write for Heated Gage Catalog.

JERGUSON
Gages and Valves for the Observation of Liquids and Level
JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities

See exhibited at Chemical Show, Booth 989

Quiet that noisy EXHAUST AIR-GAS-STEAM

PULSCO BLOWDOWN MUTE*

Eliminate ear splitting fatiguing plant noise from exhaust vents with patented PULSCO Blowdown Mutes. Capacity: From 1,500 to 500,000 cfm air and gas. 3,000 to 1,000,000 lb/hr steam. Temperatures to 1,200° F. Overall sound pressure level reduced to 80 - 86 decibels at 100 ft. Excellent silencing plus separating and collecting condensate. Drain provided.

PULSCO MULTIPLE TUBE BLOWDOWN MUTE WITH REPLACEABLE TUBE BUNDLE

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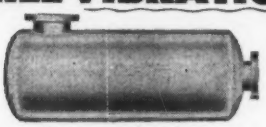
KILL VIBRATION with PULSCO



LIQUID PULSE TRAPS
Subdues Pipeline Vibration

Eliminates meter error.
Extends valve life.
For all types of rotary, reciprocating and plunger pumps.

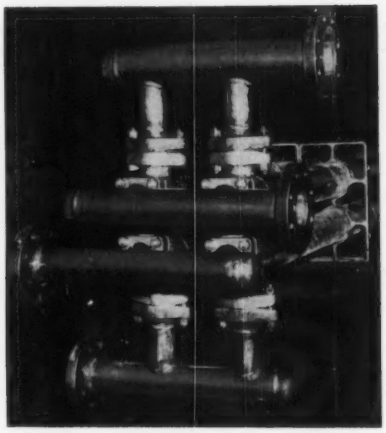
Representatives in all principal cities

PULSATION CONTROLS CORPORATION
JAckson 5-6641 P.O. Box 169 • SANTA PAULA, CALIF.

For more data on advertised products, use cards, last page.

Which grade?
50%
73%
CHEMICALS
Key chemical selection in liquid caustic
A key chemical is the best buy. Case in point: liquid caustic. We offer it in two concentrations . . . 50% and 73%. Today, your best buy may be the 50% grade. If so, that's what we'll recommend—today. But if stepped-up use of caustic or changes in freight rates alter your economic position in the future—we'll recommend conversion. We never consider our first analysis final . . . and never stop working with you.
WYANDOTTE
MICHIGAN ALKALI DIVISION, WYANDOTTE, MICHIGAN

New Equipment . . .



eration. At the plant site, foundations can be erected and piping prefabricated, so that a heat exchanger can be on stream in minutes after delivery to the job.

Several benefits occur to the purchasers of these units. First, production assemblers are able to make ready the sections at lower cost than a customer's own maintenance crew. In addition, preassembled and pretested units enable the installation to be made in shorter time, so that a new process or revamp can be started quickly.

Pretesting the units at the factory also saves hours of field testing time, and proper manifolding and alignment of the units is assured. Details are given in a new double pipe preassembled data sheet. Brown Fintube Co.

Circle E5 green card, last page

Closed Loop Process Control System Possible

The 1710 control system was introduced last March as an "open loop" system. When used in this manner, the solid-state 1710 scans instruments, feeds the data into a computer and then prints instructions telling an operator what action to take in controlling a process.

Now the loop has been closed. Utilizing two new units, the 1710 system no longer requires intervention by an operator to regulate a process. The adjustment of instrument settings can be made fully automatic.

The new additions are:

- A 1712 multiplexer and terminal unit, and
- A 1711 data converter, model 2.

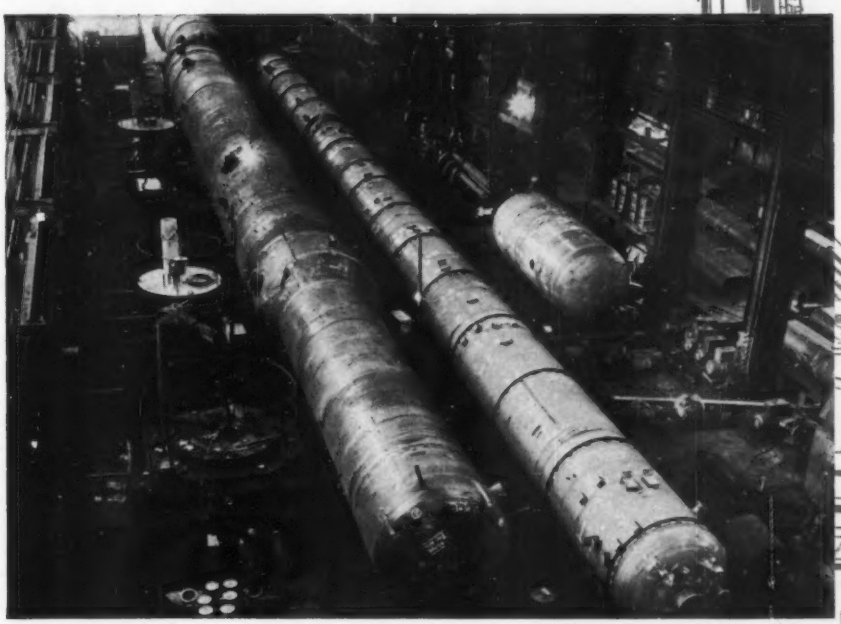
The multiplexer serves as the con-

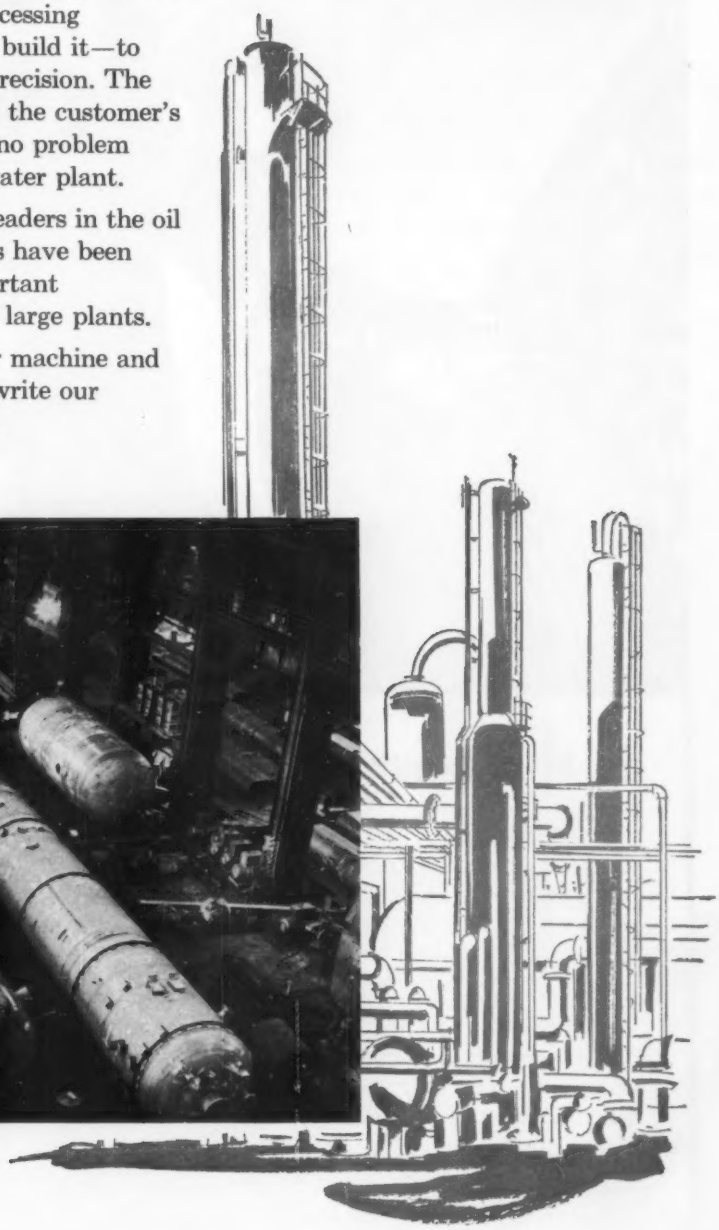
. . . to your order

Debutinizers, exchangers, fractionating towers, pressure vessels or intricate processing equipment—you name it; we'll build it—to your requirements with exact precision. The size or shape is limited only by the customer's desire. Delivery on schedule is no problem by rail or water from our tidewater plant.

For forty years engineering leaders in the oil refining and chemical industries have been calling upon Sun Ship for important components for the building of large plants.

Let Sun Ship help solve your machine and equipment problem. Phone or write our Sales Engineering Department.

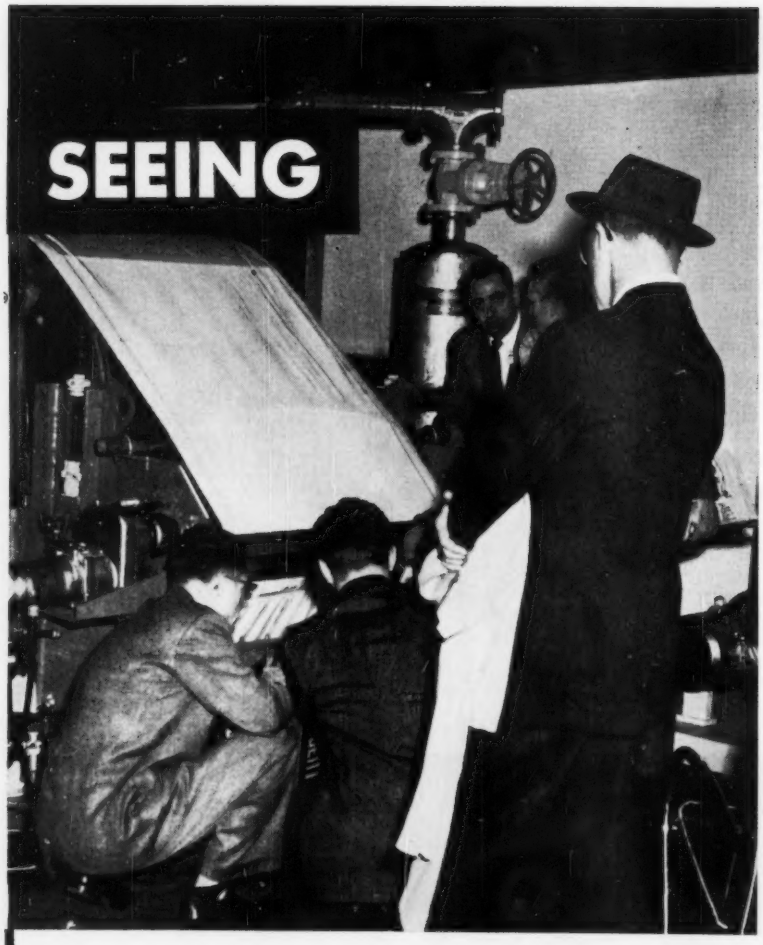




Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.



is the best answer

There is no quicker and better way to learn of new developments – to compare their relative merits–to get new ideas that may cut costs and improve your products – than to actually SEE what's new at the Exposition of Chemical Industries.

Your limited time will be well spent in studying the fact-filled displays of over 500 leading manufacturers of process equipment, materials handling, chemicals and raw materials, laboratory equipment and supplies, control instruments and automation.

Keep informed–plan your visit now, and bring your associates with you. It will more than pay you for the modest investment in time. Write for free advance registration.

27-9

28th EXPOSITION OF CHEMICAL INDUSTRIES

N. Y. Coliseum, Nov. 27—Dec. 1, 1961

MANAGEMENT: International Exposition Company, 480 Lexington Ave., N. Y. 17, N. Y.

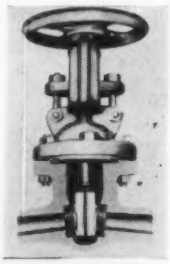
New Equipment . . .

necting link between process instruments and the control system. The data converter—specially designed to work with the multiplexer—converts instrument signals into language understood by computers. International Business Machine Corp.

Circle E6 green card, last page

New Valve Works Like Gate But Shuts Off Like Globe

"Bi-Valve" is a new type of valve that features self-conforming positive seating and absolute shutoff. The valves are designed around a swivel principle which permits the discs to individually conform to seat faces even with severe pipe strain or distortion from temperature swings. Made of steel, Bi-Valves come in sizes from 2 inches up in all pressure classes.



The valves have the inherent flow efficiency of gate valves and absolute shutoff ability hitherto thought to be exclusive in globe valves. Thus, where globe valves have been preferred in certain applications, it is now possible to use smaller pipes, valves and fittings. Under special conditions, single Bi-Valves are successfully being used in place of double valving.

Maintenance time and costs are drastically reduced using the valves, and standby valves generally are unnecessary. The discs can be changed without removing the valve from the line; they are interchangeable with solid wedges and can be reversed for wear compensation. There is no sticking when closed hot and opened cold. Galling or seizing on seating surfaces is negligible. The self-conforming discs require less spindle thrust for perfect sealing. The Chapman Valve Mfg. Co.

Circle E7 green card, last page

pH Analyzer is Reliable, Flexible and Convenient

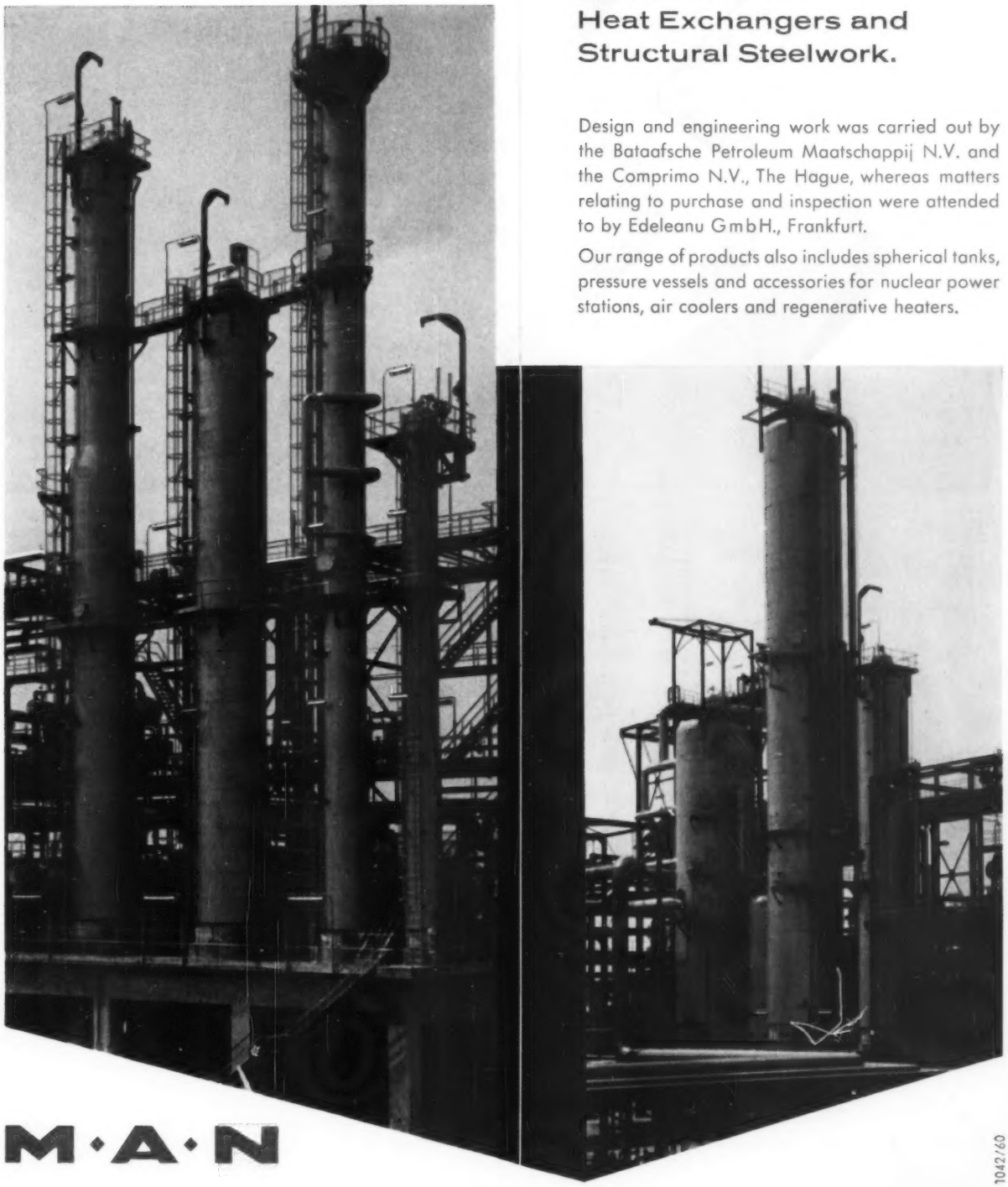
The new Model J industrial pH analyzer system incorporates the reliability, flexibility and convenience required for today's wide and grow-

In 1959 we supplied to and erected on behalf of the Deutsche Shell AG. for their Godorf Refinery the

Distillation Unit
Gas Recovery Unit
Absorber Unit
Heat Exchangers and
Structural Steelwork.

Design and engineering work was carried out by the Bataafsche Petroleum Maatschappij N.V. and the Comprimo N.V., The Hague, whereas matters relating to purchase and inspection were attended to by Edeleanu GmbH., Frankfurt.

Our range of products also includes spherical tanks, pressure vessels and accessories for nuclear power stations, air coolers and regenerative heaters.



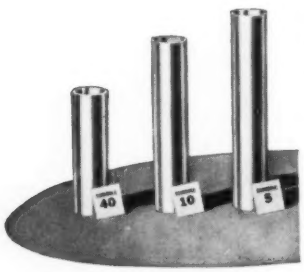
M·A·N

1042/60

MASCHINENFABRIK AUGSBURG - NÜRNBERG AG · GUSTAVSBURG WORKS

REAL ECONOMY IN PROCESS PIPING IS A MATTER OF SPECIFICATIONS—AND SPEEDLINE FITTINGS!

Make the most of both. First, be sure to check ASA B31.3 for up-to-date pressure-temperature data on critical process applications. This most recent issue of the Code for Pressure Piping certifies the use of light-wall pipe and fittings to a degree not recognized by outdated specifications.



SPECIFY LIGHT-WALL PIPE and get up to 50% more pipe for your dollar

Next, consider the installation advantages of Speedline's improved fittings design to capitalize on light-wall piping savings. Note Speedline's "tangential feature" . . . the extra length of straight on every end of every Speedline Fitting. This extra clearance eliminates alignment problems and speeds welding . . . permits joints to be readily butt-welded, flanged, or socket-welded. You choose the most practical, cost-saving joining method for your application—and one fitting can be used all ways when you specify Speedline Fittings.

Compute total savings in terms of initial costs *and* ultimate *installed* costs. Light-wall pipe and fittings, of course, cost less to begin with because they use less metal. Speedline versatility, however, adds *extra* savings in installation time and labor costs that further reduce final installed costs.

SPECIFY SPEEDLINE FITTINGS and reduce installed piping costs to a minimum

Piping standards have changed. It will pay you to be up-to-date with light-wall specifications that call for Speedline Fittings. Get details from your nearby Speedline Distributor today. He's listed on page 1494 of Chemical Engineering Catalog.

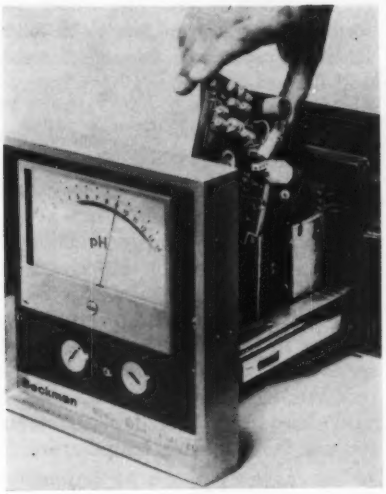
Speedline®

CORROSION-RESISTANT FITTINGS

STAINLESS STEEL • ALUMINUM • NICKEL
OTHER ALLOYS ON APPLICATION

300

A PRODUCT OF **HORACE T. POTTS COMPANY** • 566 E. ERIE AVENUE, PHILADELPHIA 34, PA.



ing range of process pH analyses.

The analyzer employs an AC stabilized amplifier which provides stability of 0.01 pH/24 hours over — 20° F to + 122° F ambient temperature range. Output accuracy and meter sensitivity is ± 0.02 pH for the full 0 — 14 pH range.

The analyzer is available with both milliampere and millivolt output for use with any potentiometric or current-type recorder. It is also available with millivolt output only.

Solid-state electronics, low cost plug-in components and circuits reduce long-term maintenance costs and simplify service. The Model J chassis slides out of the case on rails for rapid, simple inspection. By disconnecting two plugs, the entire chassis can be quickly removed from the case.

New glass and reference electrodes feature short, compact bodies for added strength. Electrode cable fastens with capscrews at electrode caps for quick connection and disconnection.

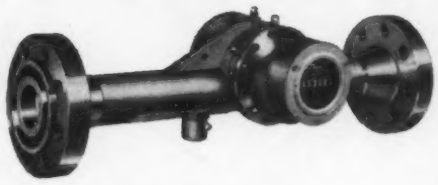
New electrode immersion and flow chambers are available for all application requirements. These units feature convenience of installation and maintenance. Beckman Scientific and Process Instruments Div.

Circle E8 green card, last page

Ball Valve Engineering Details Covered in Catalog

A new catalog provides detailed information on a complete line of manually operated and pneumatically

ROTRON WHIRL-FLO *FLOWMETERS*



A wide range of dependable flowmeters designed on the Vortex-Velocity principle to provide an economical means of accurately measuring liquid or gas flow for the chemical, oil and gas industries.

MAIN FEATURES

- High Accuracy
- Direct totalization
- Versatility of readout... direct readout of flow rate at meter or transmission to remote locations ... automatic batch control available plus ticket printing and recording
- High capacity
- Economy... low installation cost... inherently larger capacity compared with other flowmeters size for size
- Simple construction facilitates field service
- Compact, simple design permits easy installation
- Rugged construction assures reliable, long life service
- Wide range of applications for liquids or gases... handles viscous fluids... even liquids with suspended solids

GENERAL SPECIFICATIONS

Pressure Rating: 2-inch meters 1500 psig or 5000 psig; 3-inch meters and larger 2000 psig.
Pressure Drop: for liquids less than 7 psig at max. flow; for gases usually less than 100 inches water at max. flow rate.
Sizes: models available from 2-inch to 16-inch for liquids or gases.
Accuracy: depends upon meter size; usually ±0.5% or better over 10:1 span. Repeatability better than ±.2%.
Standard Materials of Construction: 2-inch meter stainless steel; other sizes carbon steel; other materials available.
Capacity: liquid capacities range from 10 to 100 gpm for the 2-inch meter to 1400-21,000 gpm for the 16-inch meter; typical gas capacities range from 100-1000 scfm at 100 psi in a 2-inch meter up to 20-150 mmscfd in a 16-inch meter at 100 psi.

ROTRON®

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ROTRON CONTROLS

division of
ROTRON MFG. CO., INC.
65 Bearsville Road, Woodstock, N. Y.

Introducing
TAPECOAT® 20

The Coal Tar Coating that provides Single-Wrap Protection PLUS an Outer Wrap... for Pipe, Pipe Joints and Other Steel Surfaces in Underground Service

TAPECOAT 20 is more than just a coal tar coating in tape form.

- ★ It's designed for single-thickness application!
- ★ It has advanced features of uniformity!
- ★ It includes a tough outer wrapper!
- ★ It assures greater coverage!
- ★ It combines 20 years of manufacturing and field application experience!
- ★ It gives superior protection with greater economy!

Write for full details today!

The **TAPECOAT** *Company*
ORIGINATORS OF PIPE AND JOINT COATING IN TAPE FORM
1555 Lyons Street, Evanston, Ill.
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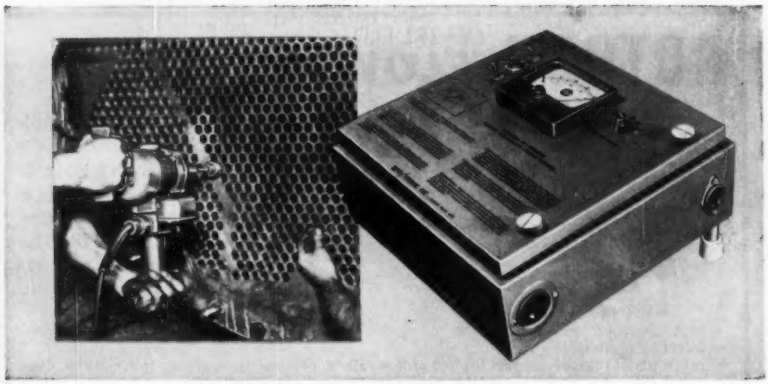


Your Motor + Wiedeke Torque Control = Increased Tube Rolling Production

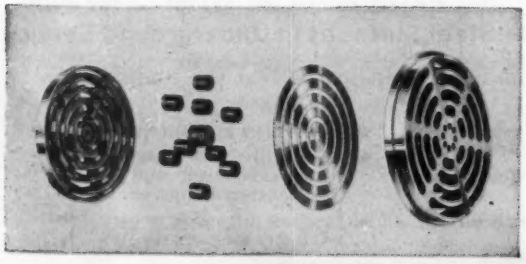
Save the cost of a new motor! New Torque Control Instrument for rolling ¼" through 4½" tubes in boilers, condensers and similar heat transfer vessels—operates with any Universal Reversible Electric Tube Rolling Tapper or Motor. Adjustable time cycle matches operator's dexterity.

The Gustav WIEDEKE Company

DAYTON 1, OHIO

VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



- up to 40% more valve area
- minimum pressure loss
- higher efficiency
- less power consumption
- normal discharge temperature
- quiet, vibration-free
- utmost safety
- lower operating costs

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

New Equipment . . .

operated ball valves. The valves described range in size from ¼ through 12 inches with screwed, socket weld, and flanged-end models for temperatures from minus 150 to 1,000° F, pressures to 1,000 psig, and vacuum to 10^{-6} mm Hg.

Two new types of ball valve seats are presented for the first time: The Graphitar seat for up to 1,000° F service (depending on pressure and service conditions); and "Fire-Seal" seat with Teflon or reinforced Teflon encaged in accurately machined metal secondary seats. The metal seats provide leaktight shutoff of flammable or hazardous fluids should plastic seats fail due to excessive temperature.

Pneumatic operators for automatic and remote on/off operation are described and illustrated. A variety of special valves, including a valve for ammonia, tetraethyl lead and other hazardous services also are shown. Additionally, five pages are devoted to suitability of standard body materials and various seat materials for a wide range of chemical services.

Dimensions and weights, material specifications, typical C_v values, pressure-temperature rating charts, and a complete page of detailed ordering instructions enable the user to select valves directly from the catalog. Hills-McCanna Co.

Circle E9 green card, last page

Refinery Fires Covered By Foam Nozzles on Wheels

A new advance in foam firefighting is the mobile foam nozzle on wheels.

The unit consists of an Aer-O-Foam PW-50 variable spray nozzle mounted on a two-wheeled running gear equipped with a drawbar by which it can be hitched to a foam truck or car. Hand grips aid maneuverability; the unit is light enough to be moved by one man if necessary. Mounted directly under the barrel of the nozzle is a cylindrical container for hose storage. When fire breaks out, the unit is moved to an advantageous point and the hose connected to a nearby foam truck or other source where foam liquid can be proportioned with water under pressure. It is now ready for operation. Handles for control of stream direction are adjustable to the operator's com-

the new Wyoming source of

SODA ASH

with Stauffer nationwide service facilities!

The completion of Stauffer's new Wyoming plant to supplement existing West End facilities will expand the market for Stauffer soda ash into areas served traditionally by Stauffer nationwide offices in supplying industrial chemicals. The large traffic department experienced in nationwide distribution problems can effect efficiency and economy in the transport of bulk or bagged soda ash from Stauffer's two natural sources. Let us suggest practical ways you can be supplied economically at your point of consumption. Simply address the coupon below and mail.

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WE ARE INTERESTED IN KNOWING THE BENEFITS TO US OF STAUFFER AS A SODA ASH SUPPLIER.

YOUR NAME_____

COMPANY_____

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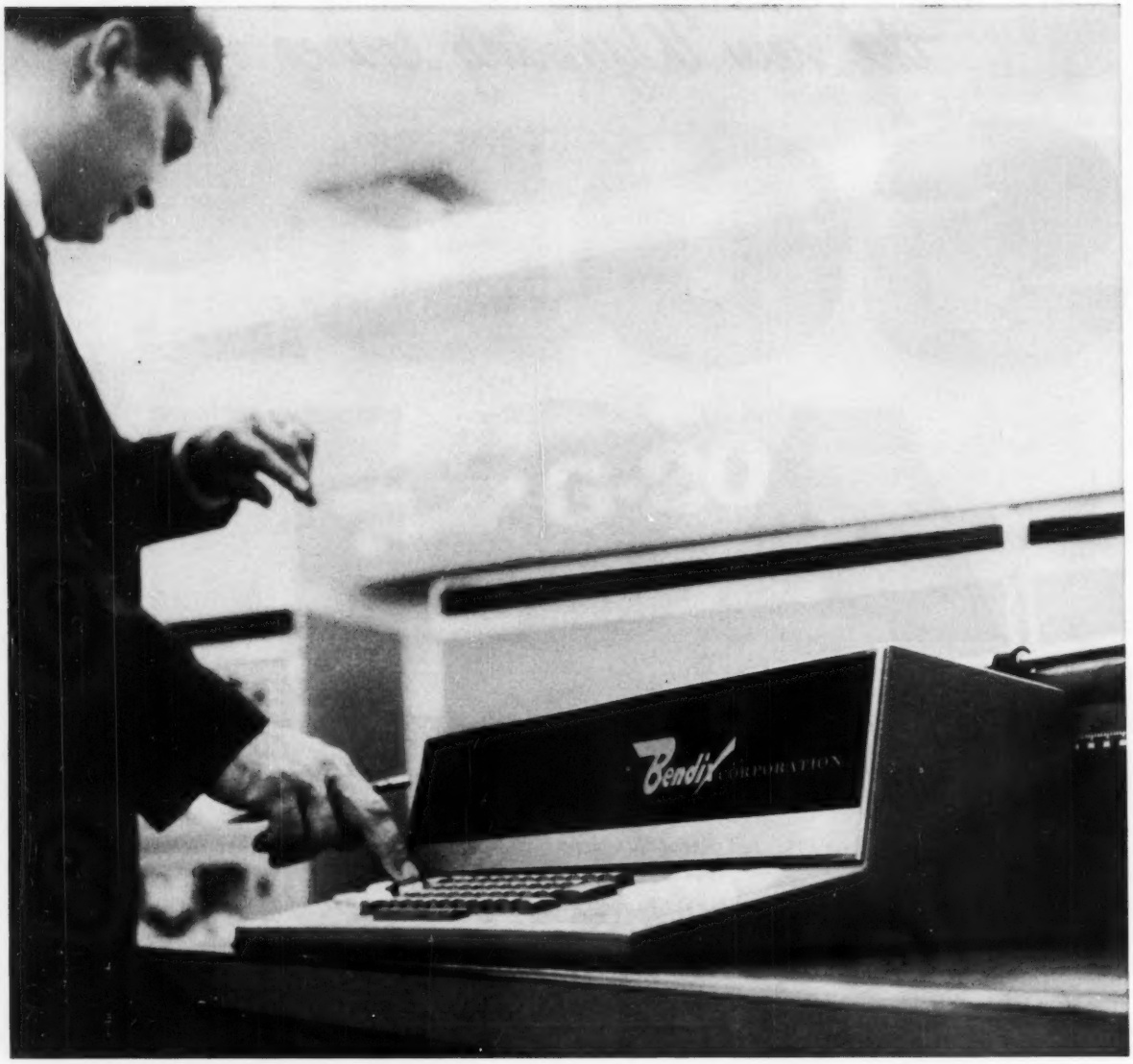
Please mail to West End Chemical Co., 636 California Street, San Francisco, Calif.

WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

SAN FRANCISCO, 636 CALIFORNIA STREET • CHICAGO, PRUDENTIAL PLAZA • ST. LOUIS 19, P. O. BOX 48



FULL SPEED AHEAD WITH THE BENDIX G-20 COMPUTER SYSTEM

The old nautical term has a new computing significance, thanks to the over-all system speed of the BENDIX G-20. Here is a modern, solid-state computing system whose high speed is not limited by input/output operations.

Blending high computational speeds with high input-output and transfer rates, the G-20 eliminates data handling bottlenecks... allows through-put (the full input-compute-output cycle) to occur at the maximum speeds of all system components. Magnetic tape transfer occurs, for instance, at 120,000 8-bit characters per second—search is performed at twice that speed. Double transition recording, high packing density, and the elimination of tape skew errors with a unique deskewing buffer provide unmatched tape system speed and reliability.

Helping the magnetic tape units assure input/output to match main frame speed is the BENDIX Data Communicator, allowing simultaneous transfer of data over as many as four channels at 120,000 characters per second each. This simultaneous capability—plus the rapid tape transfer rate—cuts conventional sorting and file maintenance times in half... provides an effective transfer rate of 480,000 characters per second.

That's why, with the Bendix G-20, your scientific, engineering, or business data processing can move "full speed ahead." Investigate the capabilities of the proven G-20 computer. Write for Bulletin BSP-05611.

Bendix Computer Division
DEPT. S-36 LOS ANGELES 45, CALIFORNIA

THE Bendix CORPORATION

fort, regardless of angle of elevation. These handles can also be secured in the ground, holding the nozzle in a stationary position.

The unit can throw a foam stream or a water stream as far as 225 feet. With a nozzle pressure of 150 psi, a straight foam stream ranging to 4,000 gpm can reach heights as great as 50 feet. A lever-action spray control handle allows the operator to change instantly, without shutting down, to any one of ten variations in pattern between full spray and straight stream. National Foam System, Inc.

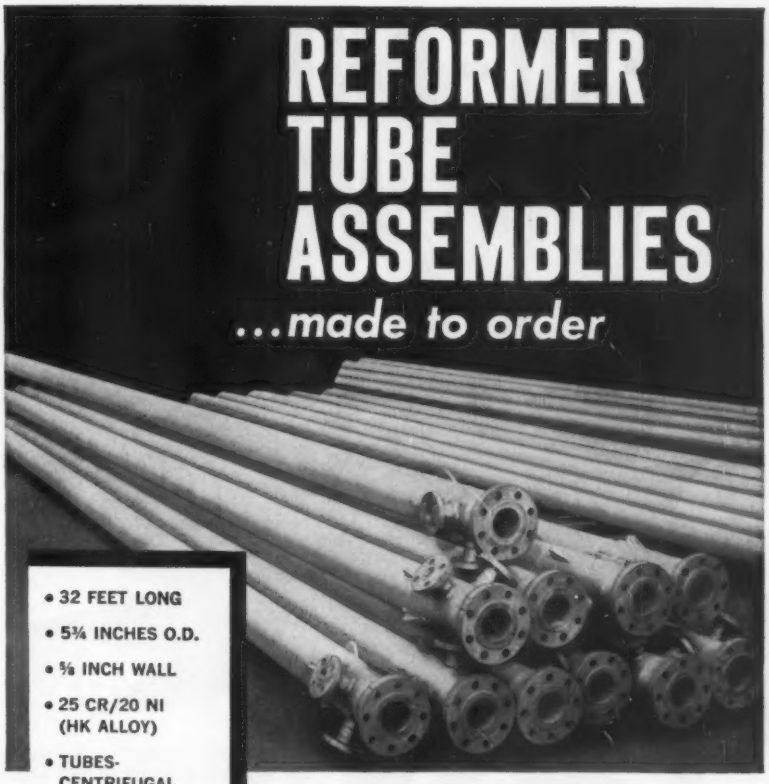
Circle E10 green card, last page

Fire Protection Valve Mounts in Any Position

A new fire protection cutoff valve with no counterweights nor interior bellows is a stainless, bolted-bonnet gate valve held open against two stainless steel springs by a fusible link. At a preselected temperature the link melts allowing the springs to snap the valve shut. The action is used to shut off the flow of flammable liquid to fire areas.

Having no counterweights, the valve may be installed in any position and requires a minimum of space and accessibility. Having no interior bellows, the valve eliminates concealed delicate working parts exposed to corrosion and presenting difficulties in inspection, maintenance, and parts replacement.

The valve is available with flanged ends in types 304, 316 and other stainless steels, in sizes from ½ to 6 inches for up to 150-pound working pressure. Exposed working parts



Alloyed to give both corrosion and heat resistance

Two of our three Casting methods are well illustrated in this photograph: centrifugally cast tubes and statically cast flanges. The finished assemblies, including the welding, typify the work turned out in our modern finishing shop.

These tubes are alloyed to meet exceptionally high temperatures—up in the 1800°F range—as well as corrosion. As a matter of fact, we have an alloy (HOM) that is good for even higher temperatures—in the 2100 to 2200°F plus range. When corrosion is the dominating problem we can offer alloys throughout the complete "C" classification.

With forty years of alloy casting experience plus complete range of both heat-resisting and corrosion-resisting alloys plus facilities for finishing and assembling, Duraloy is in a strong position to take care of your high-alloy casting requirements. Ask for Bulletin G-261.

DURALOY

ALLOY CASTING INSTITUTE ACI MEMBER

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For more data on advertised products, use cards, last page.

EXO-ANNEAL YOUR WELDS!

EXO-ANNEAL is simple, quick, automatic. Just two steps to heat treat field welds: (1) fasten EXO-ANNEAL kit around weld area, (2) ignite. Treatments are designed to provide desired improvement in corrosion resistance, physical properties, residual stress. Kits are made for all weldments regardless of size, shape, or composition.

. . . save time and expense even on the most complicated jobs

Stress relieving field welds by EXO-ANNEAL **controlled exothermic reaction** is now the fastest, most economical heat treating method. ■ EXO-ANNEAL permits any number of welds to be stress relieved simultaneously without constant attention. Only one-half to three man-hours are required per pipe joint treatment. ■ Unskilled labor can handle EXO-ANNEAL safely, quickly . . . without expensive capital equipment. Built-in temperature control eliminates need for thermocouple measurement. ■ EXO-ANNEAL is custom-tailored to individual pipe geometry, chemistry, location and required heat cycle . . . as well as non-standard weldments, solution treatments, unusual stress-relieving jobs. ***For engineering assistance on your field heat treating problem or technical information on EXO-ANNEAL, contact:***

EXOMET

EXOMET INCORPORATED

Maple Avenue • Conneaut, Ohio

EXOTHERMIC METALLURGICAL PRODUCTS

New Equipment . . .

are entirely surrounded by a perforated-metal protective cage on a cast-steel frame. Ready removal of the cage exposes all working parts for inspection and simple test. Following testing, the inexpensive link, held by two pins, is readily replaced. Links are available for a choice of different temperatures. If necessary the valve may be reset without link replacement permitting, for example, draining of a fire-endangered tank to a safe area. Valve and Fitting Div., Cooper Alloy Corp.

Circle E11 green card, last page

Distillation Equipment Described in Brochure

A new eight-page brochure on distillation equipment for the chemical and petroleum industries has a special section on distillation columns. The use and design of three principal types of trays—bubble cap, sieve and valve—are reviewed.

It includes a discussion, with illustrations and photos, of one-piece tray construction, cartridge and sectional-type trays, sectional tray designs, standard solvent stills and other accessory equipment. Process Equip. Dept., Struthers Wells Corp.

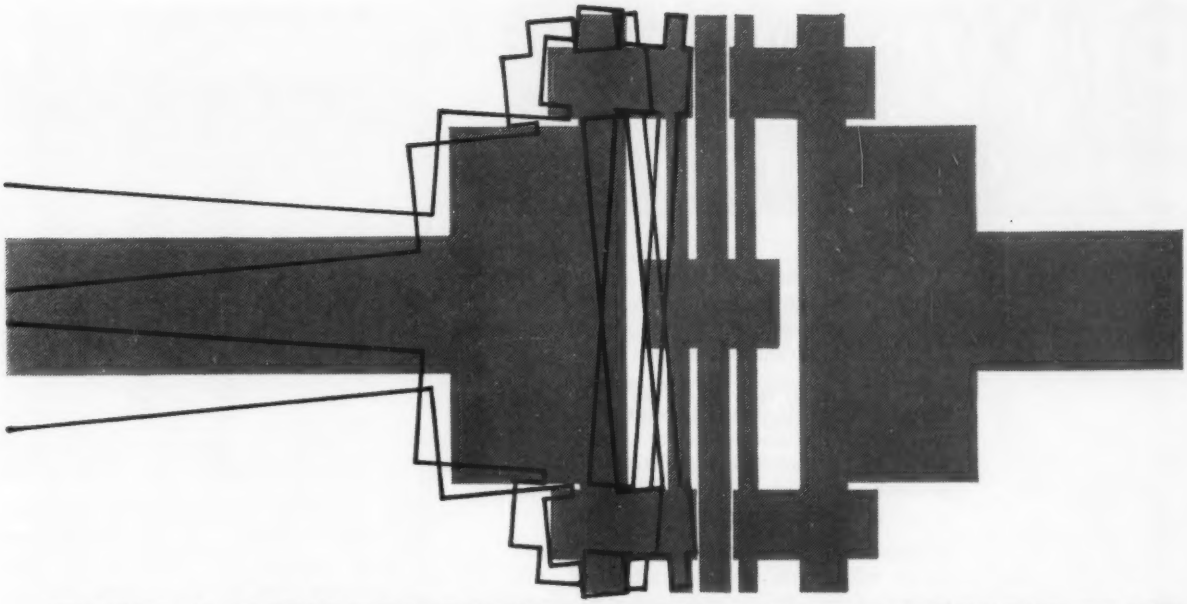
Circle E12 green card, last page

Separator, Trap Combine To Remove Oil and Water

A new low cost system has been developed for removal of oil and water from compressed air, gas and steam lines.

The system, consisting of a "T" type separator, combined with the proper trap for the particular application, is both light weight and compact enough to be installed and supported in the line at any point. Engineers point out that installation of a trap alone, where the problem of entrained moisture is encountered, is not sufficient. If a separator is not used, a high percentage of moisture will by-pass and elude the trap. The problem then becomes one of finding the combination of separator and trap designed specifically to work together capacity-wise, operation-wise, space-wise and at a cost that is not prohibitive.

The company has simplified selec-

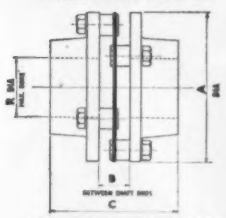


THE LATEST METASTREAM COUPLING

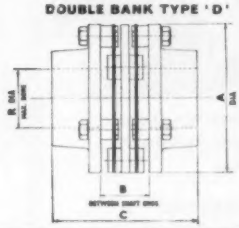
the NEW DIS series

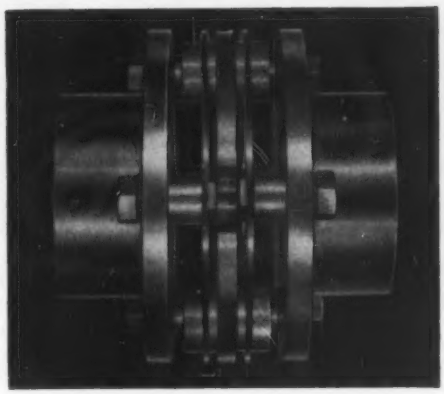
A power transmission coupling having all the merits and advantages that are inherent in the unique Metastream design, and available at **NEW, LOW PRICES. THE MOST OUTSTANDING VALUE EVER OFFERED.** Supplied in spacer, non-spacer and single and double/bank types, ex stock.

SINGLE BANK TYPE 'S'



DOUBLE BANK TYPE 'D'





Specification Table

Size of Coupling	Max. Rating Hp/Rpm	A	B	C	R Max. Bore	Size of Coupling	Max. Rating Hp/Rpm	A	B	C	R Max. Bore
D.I.S. 1/S	.002	$1\frac{7}{8}$″	0.477″	1.477″	$\frac{5}{8}$″	D.I.S. 1/D	.002	$1\frac{7}{8}$″	0.93″	1.93″	$\frac{5}{8}$″
D.I.S. 3/S	.005	3.45″	0.6125″	2.8625″	$1\frac{1}{4}$″	D.I.S. 3/D	.005	3.45″	1.125″	3.375″	$1\frac{1}{4}$″
D.I.S. 6/S	.010	$4\frac{13}{32}$″	0.83″	3.83″	$1\frac{3}{4}$″	D.I.S. 6/D	.010	$4\frac{13}{32}$″	$1\frac{7}{16}$″	$4\frac{7}{16}$″	$1\frac{3}{4}$″
D.I.S.12/S	.020	$5\frac{31}{32}$″	$\frac{29}{32}$″	$4\frac{13}{32}$″	$2\frac{1}{8}$″	D.I.S.12/D	.020	$5\frac{31}{32}$″	1.764″	5.264″	$2\frac{1}{8}$″
D.I.S.24/S	.040	$6\frac{31}{32}$″	$\frac{7}{8}$″	$5\frac{7}{8}$″	$2\frac{3}{4}$″	D.I.S.24/D	.040	$6\frac{31}{32}$″	1.792″	6.792″	$2\frac{3}{4}$″

METADUCTS LIMITED CATHERINE WHEEL ROAD BRENTFORD MIDDX Tel: ISL 6441

A MEMBER OF THE CONCENTRIC GROUP OF COMPANIES

P.6905

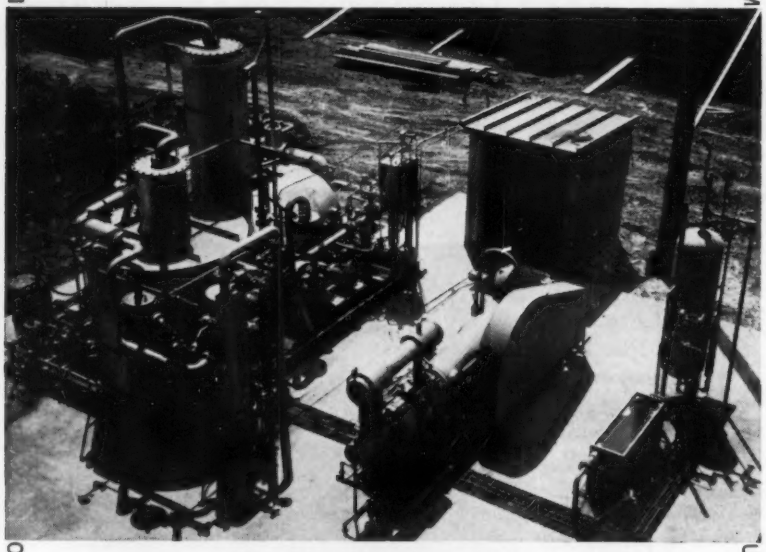
For more data on advertised products, use cards, last page.

THE STANDARD LOOK: SELF-GENERATING GAS SYSTEMS

A few short years ago most of the gas used in the petroleum processing industry came in bottles trucked in from large gas generators. The big cost of the gas was in the handling.

EFFICIENT SMALL GENERATORS were perfected by Gas Atmospheres engineers. Labeled "Packaged Gas Systems", they made it profitable for even users of limited amounts of gas to operate their own systems.

HIGHEST PURITY GASES can now be produced with these smaller units, and complete storage, drying and purifying equipment is available.



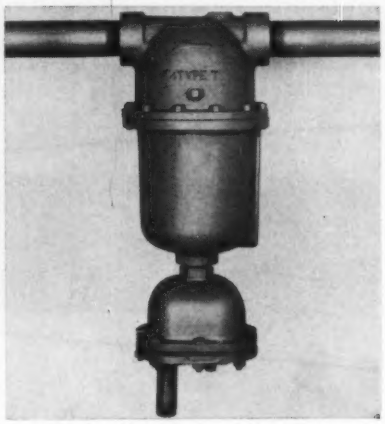
10,000 cfh Gas Atmospheres nitrogen generator/compressor system in operation at the Baytown Refinery of Humble Oil & Refining Company.

PACKAGED GAS SYSTEMS are designed for volumes from 50 cfh to 50,000 cfh. Complete systems for the production of nitrogen, carbon dioxide, hydrogen, inert, reducing and annealing gases are better engineered by *Gas Atmospheres, Inc., 5353 West 161st Street, Cleveland 35, Ohio.*

gas Atmospheres, inc
equipment for producing industrial gases

PETROLEUM PROCESSING PETROLEUM PROCESSING PETROLEUM PROCESSING PETROLEUM PROCESSING

New Equipment . . .



tion of the components for pressures ranging from 150 to 1,000 psi and for pipe sizes ½ to 8 inches. The compactness of the system permits installation near point of use which is important, since this eliminates the possibility of further condensate developing downstream. Wright-Austin Co.

Circle E13 green card, last page

4-Page Data Sheet Covers Automatic In-Line Blending

A new four-page data sheet describes digital and analog systems for automatic in-line blending.

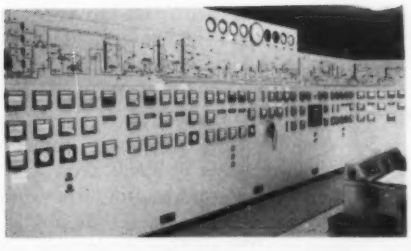
Heart of the system is the Pottermeter turbine flow meter, one in each component line to be blended. Each flow meter transmits its electrical signal to the remote instrumentation blending control which by automatic operation of control valves maintains a consistent, accurate product blend to accuracies of as high as plus or minus 1/10 of 1 percent.

This system can be supplied to handle flow rates as low as 1/10 of a gpm and greater than 25,000 gpm. The flow meters and instrumentation lend themselves readily to complete automation, data logging, and all types of process control. Potter Aeronautical Corp.

Circle E14 green card, last page

Pump and Valve Packing For Many Corrosive Fluids

An improved Teflon, specifically developed for braided packing for pumps and valves, shows promise of economically replacing conventional pump and valve packing ma-



IN OCTOBER 1960 The C. W. Nofsinger Company started the design engineering of a Benzene Plant for El Paso Natural Gas Products Company. The prime objective was the earliest possible completion date.

The plant includes *four new units:* A Unifiner, a Platformer, a Udex Unit and a Hydeal Unit. In addition a complete *revamp of the Crude Unit* was required, together with all *offsite facilities* necessary for the project.

In order to produce a limited amount of Benzene AS SOON AS POSSIBLE, the Udex Unit and Hydeal Fractionation Section were completed first and went on stream June 10, 1961.

The Unifiner and Platformer were placed in operation August 1. The revamp of the Crude Unit was completed during the latter part of August, and the entire plant was on stream shortly after *September 1.*

These early completion dates are a tribute to the CLOSE COOPERATION between the personnel of El Paso Natural Gas Products and the other companies involved in the project.

"In Engineering it's the PEOPLE that count"

THE C. W. NOFSINGER CO.

Engineers and Contractors for the Petroleum and Chemical Industries

307 East 63rd Street **Kansas City 13, Missouri**

West Coast: A. R. CHANDLER, 617 S. Olive St., Los Angeles 14, Calif.
Gulf Coast: RUSSELL G. DRESSLER, 204 Carolwood Dr., San Antonio, Texas.
East Coast: L. C. "LOU" RUBIN, 46 Francisco Ave., West Caldwell, N. J.

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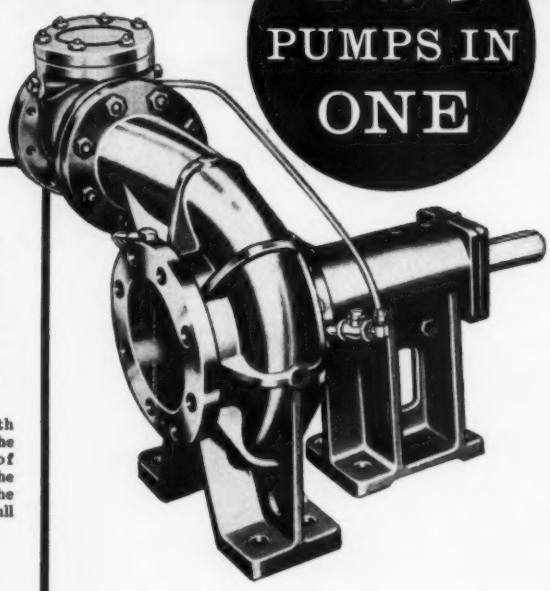
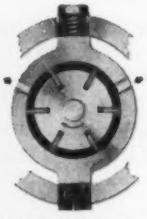
OVERCOME CRITICAL NPSH CONDITIONS WITH *ROTO-PRIMES*

TWO PUMPS IN ONE



Full Priming—With air or vapor in the lines, pressure of spring on top of the movable slide holds the priming pump in full priming position.

Partial Priming—As the pump evacuates air and vapor from the lines, liquid pressure builds up on the underside of the slide, moving it upward toward neutral.



Neutral—When all air and vapor are removed, liquid pressure equalizes spring pressure and the pump automatically slides into neutral...where it remains until air and vapor again appear in the system.

Having trouble with loss of available NPSH when pumping liquid hydrocarbons? Here's your answer — Gilbarco Roto-Prime centrifugal pumps. Roto-Primes are a unique integral combination of a high efficiency centrifugal pump and a variable-capacity positive vane type. Vane pump automatically goes into operation whenever air or vapor enters the centrifugal inlet, providing fast, positive automatic self-priming. These pumps, therefore, *will continue to operate when available NPSH drops below normal requirements.* The 4" x 3" models, as an example, will pump air or vapor from 50 feet of four-inch pipe in less than 60 seconds. Capacities up to 1,600 G.P.M.

Write today for catalog and full information:

Gilbarco

Gilbert & Barker Manufacturing Co.
West Springfield, Mass.
Toronto, Canada

New Equipment . . .

terials subjected to a broad spectrum of corrosive fluids.

Tests show the new packing material is much less sensitive to the effects of operational and frictional heat, and more receptive to gland adjustment than the earlier fiber. This results in greatly improved service life, particularly in high-speed rotary pumps, and reduces markedly the need for special installation and break-in techniques.

Improved performance is attributed to complete removal of all carbonaceous material from the Teflon by bleaching and pre-shrinking the fiber prior to braiding. Removal of carbon eliminates the sources of exothermic heat resulting from oxidation of the carbon, and reduces the packing's tendency to "burn." Preshrinking of the yarn before braiding results in greater dimensional stability at high temperatures, reducing the packing's tendency to change dimensions in service.

The outstanding properties of the new packing material—resistance to flow, self-lubrication, chemical inertness, and a wide operating temperature range—offer a number of advantages. E. I. du Pont de Nemours & Co.

Circle E15 green card, last page

New Processed Steel Resists Hi-Temp Corrosion

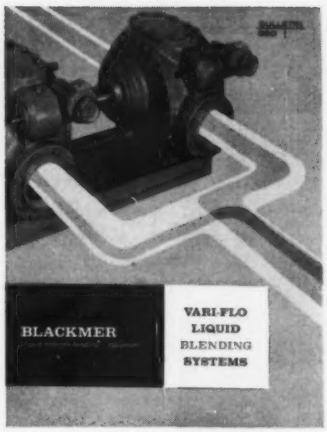
Data sheets describing new aluminium-impregnated steels for high-temperature, corrosive service are now available.

In-service performance of the proccessed steels during more than two years has demonstrated the particularly high degree of resistance to sulfur-bearing atmospheres at metal temperatures up to and beyond 1,600° F and gas temperatures as high as 2,200° F.

As distinct from other processes involving aluminum protection, MLSCO-A/11 forms no exterior coating which can peal, chip, crack or exhibit porosity. Rather, resistance to corrosion and oxidation is accomplished entirely by furnace impregnation at elevated temperatures.

Moreover, the resulting iron-aluminum alloy layer ranges in depth as high as .035 inches, depending upon time of processing and the controls maintained. Hence, there is no coat-

FUEL OIL BLENDING WITH PUSH BUTTON TENDING



IN-LINE BLENDING FOR ANY BUDGET

New Blackmer Vari-Flo in-line blending systems score again with fuel oil distributors and dealers. You simply dial the blend ratio with this unique system, blend components right in the pipeline, deliver directly into tank trucks. Eliminate stratification, speed loading time. Reduce requirements for storage tanks, piping and inventory of blended stocks. Extremely accurate and automatic, yet easy and inexpensive to operate and maintain. Vari-Flo Systems are proven in the field—blending intermediate grades to meet exacting industrial demands. Let us show you what Vari-Flo Blending has done for other operations like yours. **See us in Refinery Catalog or write for free Bulletin 650F.**

"liquid materials handling"® equipment

BLACKMER / *blending systems*

BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICHIGAN

DOUBLE

the length of filter runs

Over 30 years of use in a variety of industrial and other installations have shown that Anthrafilt will give filter runs approximately twice as long as sand or quartz. Rates up to 200 mgad are obtainable with less clogging and packing than similar media.

PLUS these other advantages:

Requires only half as much wash water . . . Keeps filters in service longer periods . . . Increases filter output . . . Gives better support to synthetic resins . . . Better removal of fibrous materials, micro-organic matter, etc. . . . Ideal for industrial acid and alkaline solutions . . . Effective filtration from entire bed . . . Less coating, caking or balling with mud, lime, iron or manganese.

ANTHRAFILT®

The Original Carbonaceous Filter Medium

A Product of

ANTHRACITE EQUIPMENT CORP.

Main Office:
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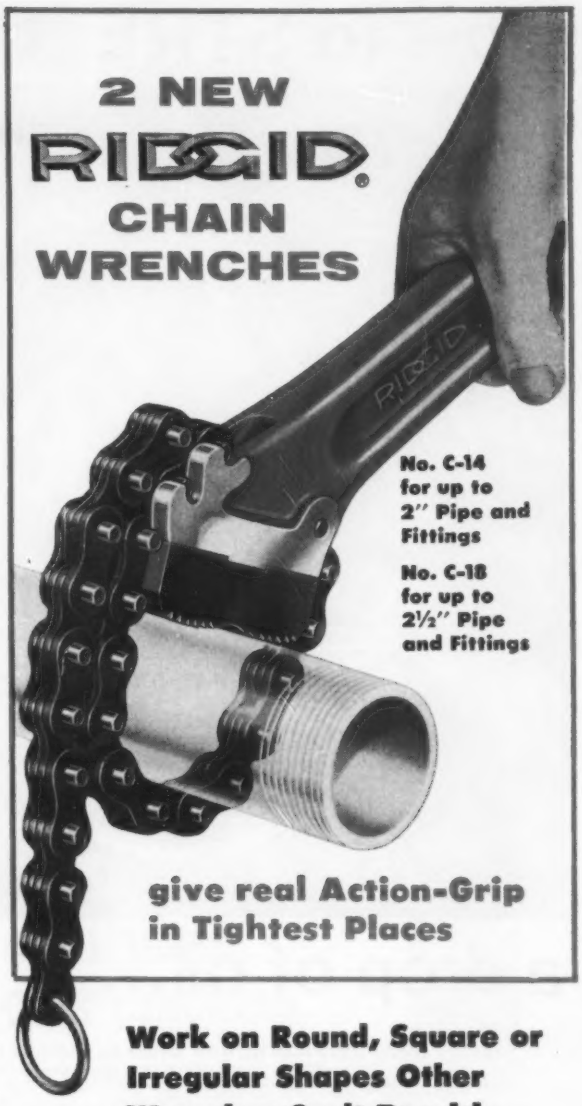
Sales and Engineering:
P.O. Box 1696, Erie, Pa.
Phone: GL 4-3901

2 NEW RIDGID® CHAIN WRENCHES



No. C-14 for up to 2" Pipe and Fittings

No. C-18 for up to 2½" Pipe and Fittings

give real Action-Grip in Tightest Places

Work on Round, Square or Irregular Shapes Other Wrenches Can't Reach!

In extra close quarters, there's nothing that'll beat these new RIDGID Chain Wrenches for getting the job done. Fast, ratchet-like action in either direction . . . from either side. Give tight grip without crushing. Large, easy-to-grab end ring for fast chain adjustment. Tempered steel chain locks securely . . . releases quickly. Rugged, comfort-grip, I-beam handle, guaranteed not to break or warp . . . handy hang-up hole.

Light and easy to use, these new RIDGID Chain Wrenches do everything a regular wrench can do . . . and much more. Call your Supply House and get one today!

RIDGID®

The Ridge Tool Company • Elyria, Ohio, U.S.A.

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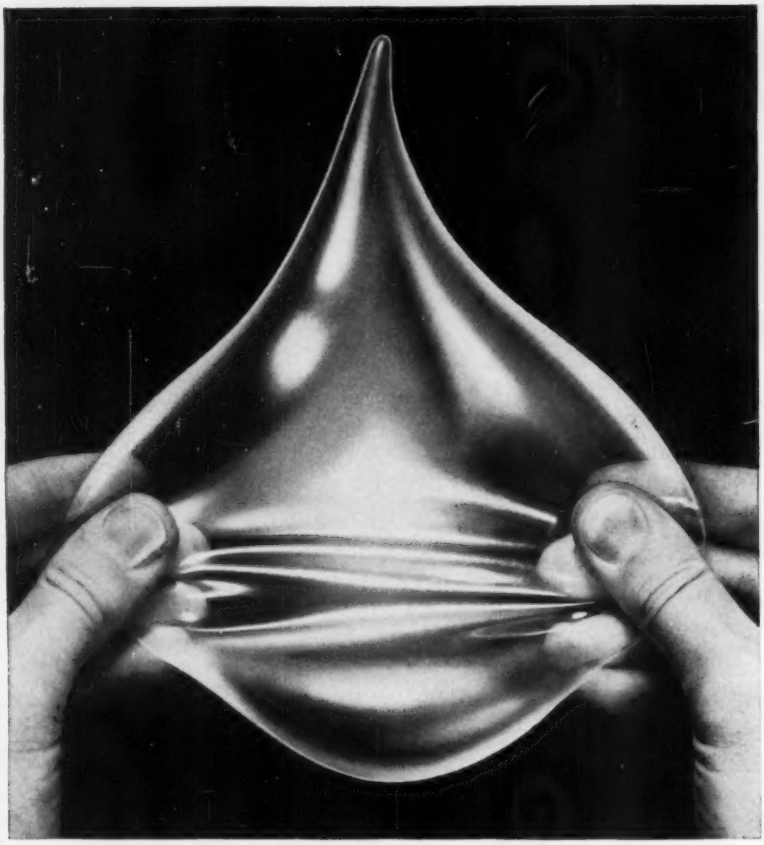
How to STRETCH



a drop of oil...

Manzel force-feed lubricators squeeze the full potential out of every drop of oil you purchase. Model "94", for example, pumps against pressures up to 3,000 pounds, handling any grade of oil from the lightest mineral oil to the heaviest cylinder stock with the same regularity. Model "94" starts, stops, speeds up and slows down in synchronization with your machinery. Every change in engine speed brings a corresponding change in the amount of oil delivered. For details on our whole line of *responsive, responsible* lubricators, write for our catalog. Manzel, 256 Babcock Street, Buffalo 10, New York. For the most efficient lubrication,

ask the man from

A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

New Equipment . . .

ing, but rather only solid metal.

A high surface hardness averaging Rockwell C-60 affords resistance to erosion, abrasion and impingement of high velocity gases.

All carbon, alloy and stainless steels can be so processed and the aluminum-impregnated steels are readily weldable without loss of protection.

As for cost, the processing standard alloy tubes or castings may be one-third to one-half that of the steel product itself. Corrosion Tubing Div., M. L. Sheldon & Co.

Circle E16 green card, last page

Low Cost Steam Generator Makes 150,000 Pounds/Hr.

An actual steam generator (4 feet high, 3 feet diameter), not a model, designed for producing 150,000 pounds per hour or a variety of capacities and pressures, operates on hydrogen peroxide, gaseous hydrogen and water. The peroxide is decomposed catalytically and the oxygen in the decomposition products is afterburned with a small amount of gaseous hydrogen to make highly superheated steam. Water is added to reduce temperature and increase steam weight flow. Here are some of the major advantages of the Hyprox steam generator:

- Extremely compact.
- Initial cost is extremely low. A complete steam generating system including the cost of propellant (fuel) tanks would be about $100,000. This compares with a multi-million-dollar expenditure for a steam boiler installation of similar capacity.
- On stream in a hurry. The generator can be in operation in less than three months as compared with a year or possibly two required for a complete steam boiler installation.
- No warm-up required. To supply such high pressure steam, conventional power plants would have to operate approximately three hours. The unit is in complete operation at the push of a button.
- Start-stop operation. The unit is designed specifically for start-stop operation and intermittent service. When conventional steam power plants are used in this manner, maintenance costs are extremely high.
- Spontaneous ignition. No pilot light or sparking is required, since

Refractory insulating concrete linings keep cats cracking

Refractory insulating concrete, bonded with LUMNITE calcium-aluminate cement, is being used more and more to line regenerators, cyclones, strippers, catalysts and reactor transfer lines of fluid catalytic cracking units. On stream in FCCs across the country, these industrial concrete linings will resist severe erosion and abrasion caused by catalyst fines ... resist attack by acid condensate ... and provide insulation at high temperatures.

Installation of monolithic concrete linings is fast, easy, economical – whether cast in place, gunited or plastered. Concrete reaches service strength in 24 hours.

For added convenience, castables bonded with LUMNITE cement are available from leading manufacturers of refractories. These are packaged mixtures, ready for use with just the addition of water. For more information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

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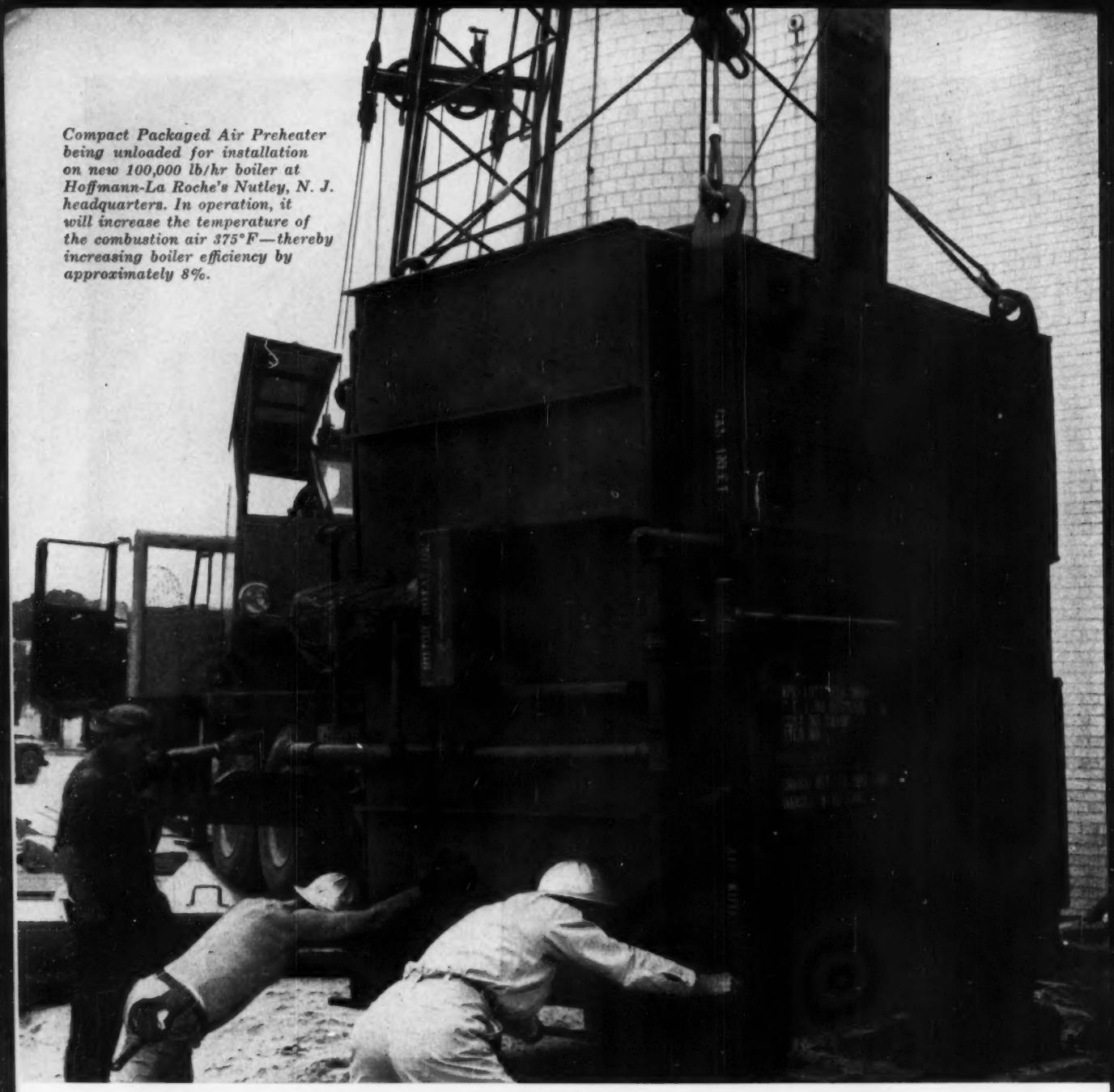
Universal Atlas Cement
Division of
United States Steel



Compact Packaged Air Preheater being unloaded for installation on new 100,000 lb/hr boiler at Hoffmann-La Roche's Nutley, N. J. headquarters. In operation, it will increase the temperature of the combustion air 375°F—thereby increasing boiler efficiency by approximately 8%.

PACKAGED AIR PREHEATER

WILL RECOVER 330°F FROM NEW BOILER FOR HOFFMANN-LA ROCHE INCORPORATED

Hoffmann-La Roche, one of the leading producers of pharmaceuticals, vitamins and aromatic chemicals, specified a Ljungstrom Packaged Air Preheater for their new boiler for three reasons: 1) This compact, preassembled unit is ready to run as soon as it's connected to the power line and ducts—no extra installation or erection costs; 2) The unit occupies only about 450 cubic feet of space but will cut boiler exhaust temperatures from 680°F to 330°F—for about 8% saving in fuel; 3) Savings in fuel alone—roughly 1% for every 40°F drop in exit gas temperature—can pay for the unit in two short years!

Packaged Ljungstroms are available in sizes for use on boilers in the 25,000 to 250,000 lb/hr range—can give you these same fuel saving advantages. For full information, write today for our 14-page Packaged Air Preheater booklet.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

The premium thermocouple wire with metal sheath and mineral insulation (.020" to .500" O.D.) for universal application especially when high temperatures, high pressures, or space limitations are factors, and for sensitivity and quick response.

Many sizes in I.S.A. calibrations with 304 stainless steel or Inconel sheath and MgO insulation carried in stock. Hundreds of other combinations may be ordered to suit conditions.

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BULLETIN 1-500
Thermocouples
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Terminations
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9666

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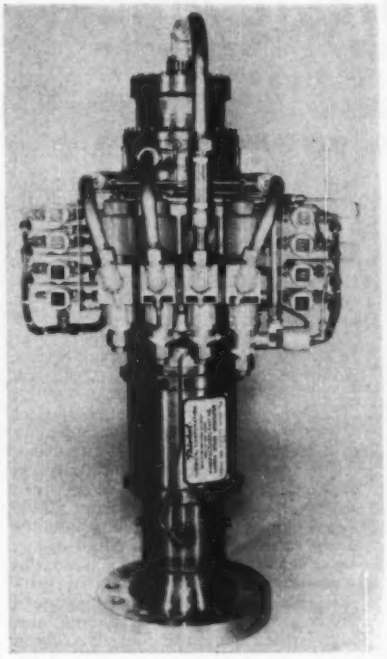
New Equipment . . .



the ignition is controlled through temperature variation.

• Controlled steam. The generator provides complete control over the quality, temperature and pressure of the steam resulting from the injection of the water into the combustion products. Steam is pure and condensible.

• No supporting equipment is required. Installation is simple.

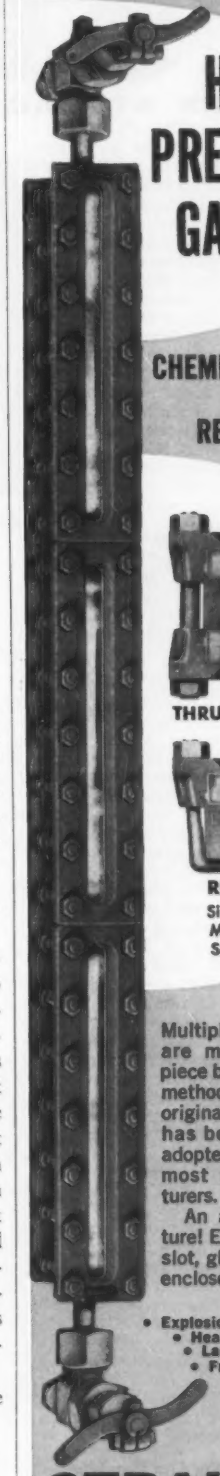
The relatively high cost of hydrogen peroxide makes the generator too expensive for continuous steam production at this time. Its major anticipated use in the process industries is in installations where intermittent peak loads of extremely high pressure and high flow steam are required. It is also expected to see wide use in laboratory and pilot plant operation where it is desirable to experiment with results at high pressures and high flow rates. A further application is its potential use as an emergency standby unit where continuous system operation is critical. Croll-Reynolds Co.

Circle E17 green card, last page

Bulletin Covers On-Stream Descaling of Exchangers

A new, quick-reading description of the latest materials and methods in use for on-stream descaling of

Strahman



HIGH PRESSURE GAUGES

FOR CHEMICAL PLANTS AND REFINERIES

THRU VISION

REFLEX
Single or Multiple Sections

Multiple section gauges are made with a one piece body chamber. This method of construction, originated by Strahman, has become generally adopted as standard by most gauge manufacturers.

An added safety feature! Except for visibility slot, glass is completely enclosed.

- **Explosion proof illuminators**
- **Heated or cooled gauges**
- **Large Chamber Gauges**
- **Frost-proof extensions**
- **Tubular Gauges**
- **Gauge Cocks**

STRAHMAN VALVES INC.
NICOLET AVE., FLORHAM PARK, N. J.

For more data on advertised products, use cards, last page.

PROTECTOSEAL

TSE *fire prevention and vapor control*

TANK STORAGE ENGINEERING

In the chemical process industries, particular emphasis must be placed on vapor controls and fire prevention when planning tank storage.

Operating vents installed on flammable liquid storage tanks must incorporate flame arresters. Functionally, the flame arrester protects a tank's contents from fire and explosion by dissipating or reducing the temperature of the exterior flame below the ignition point of vapors on the interior side of the arrester.

Tank operating vents manufactured by The Protectoseal Company are of two basic types: Conservation and Non-Conservation. Conservation Vents (Fig. 1) are designed for installation on tanks where it is desirable

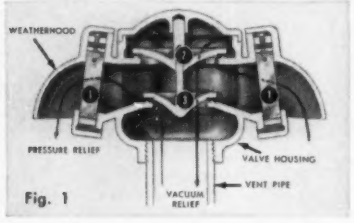


Fig. 1

to reduce evaporation losses. Non-Conservation Vents are often referred to as "free vents" because they are open at all times to permit free flow of air into or out of the tank.

Conservation Vents are equipped with automatically operating vacuum and pressure relief valves which are weighted to relieve at designated settings. The vacuum relief valve (2, Fig. 1) controls the intake of air, and the pressure relief valve (3, Fig. 1) controls the escape of vapors to the atmosphere. Both valves open and close to permit only that intake or outlet relief necessary to keep interior pressures within permissible working limits and avoid damage to the tank.

The flame arresters incorporated in Protectoseal Vents consist of a series of rectangular plates assembled on a single rod to permit rotation of the plates for cleaning. Embossings on the face of each plate provide the correct, uniform air spacing for the flame arresting function.

The flame arrester in Protectoseal Vents is located outside the valve housing to permit easy access for cleaning. Another advantage of placing it outside the housing, in the case of Conservation Vents, is that the arrester protects the valves against atmospheric dirt and weather. In the event of ignition, the vent burns at the arrester, rather than at the valves, thus avoiding warping and distortion of the valve structure.

Emergency Vents For Fire Conditions

In addition to the normal venting capacity provided by the operating vent, every large above-ground flammable liquid storage tank should be provided with some means of relieving excessive internal pressure build-up caused by exposure of the tank to fire. (For tanks of moderate size, the operating vent can be made large enough to serve also as an emergency relief vent). The heat of fire occurring near a flammable liquid storage tank transmitted through the wall of the tank, causes the liquid to vaporize readily. In some petroleum products, this vaporization amounts to roughly 30 or more cubic feet of vapor for every gallon of liquid vaporized. This could generate a relatively high pressure within the confined area of the tank's vapor space. Lacking sufficient emergency relief, an explosion could occur.

Explosions caused by such conditions may be readily avoided by providing adequate emergency vents which permit vapors to escape and burn quietly at the outlets. These emergency vents usually take the form of metal poppet valves (Fig. 2) which are weighted to stay closed under normal pressure conditions and open only when a pre-determined pressure is attained.

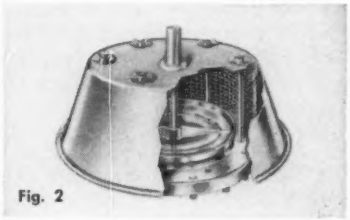


Fig. 2

The Protectoseal Series 7800 Emergency Relief Valve embodies a free-lifting, self-closing valve. A vapor tight metal-to-metal seat is provided by a machined surface on the flanged aluminum base and the underside of the valve. A non-metallic seat can be provided to meet special operating conditions. A weatherhood and a coarse mesh screen covers the entire valve structure.

Technical Assistance Offered

Protectoseal Engineers have long experience in solving corrosion, sublimation, and vapor conservation problems in connection with tank venting equipment. You are invited to submit your problems for analysis and recommendations. TSE—Tank Storage Engineering—is a periodical publication of the Protectoseal Company which provides useful and informative data on the selection, application, and maintenance of storage tank vents, fittings, and related equipment. We will be glad to add your name to the mailing list. There is no obligation. Write:

THE PROTECTOSEAL COMPANY / 1942 South Western Avenue, Chicago 8, Ill.

New Equipment . . .

heat exchange equipment contains a diagram illustrating a typical on-stream descaling procedure and detailed product descriptions of the most successful materials being used for this operation.

The bulletin, entitled "Avoid Production Losses . . . Try On-Stream Descaling of Heat Exchange Equipment," also includes much valuable general information about descaling of water-cooled equipment used in petroleum, petrochemical and chemical processing operations. Oakite Products, Inc.

Circle E18 green card, last page

Thermocouple Catalog Has Information on 150 Items

A new 12-page catalog on SERV-RITE insulated thermocouple wire, thermocouple extension wire, and multi-pair extension cable gives complete information on the insulation, sizes, etc. It includes prices and other ordering information on over 150 standard items that meet most of the common industrial requirements. Claud S. Gordon Co.

Circle E19 green card, last page

Automatic Control Theory Explained in Manual

A 12-page technical manual on "Generalized Control Theory" explains with text and many examples the basic theories in automatic fluid control. It was written by a staff member of Fisher's systems analysis group, and is one of a series on this important area in the control field.

The booklet is intended either as a primer for those starting a study

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

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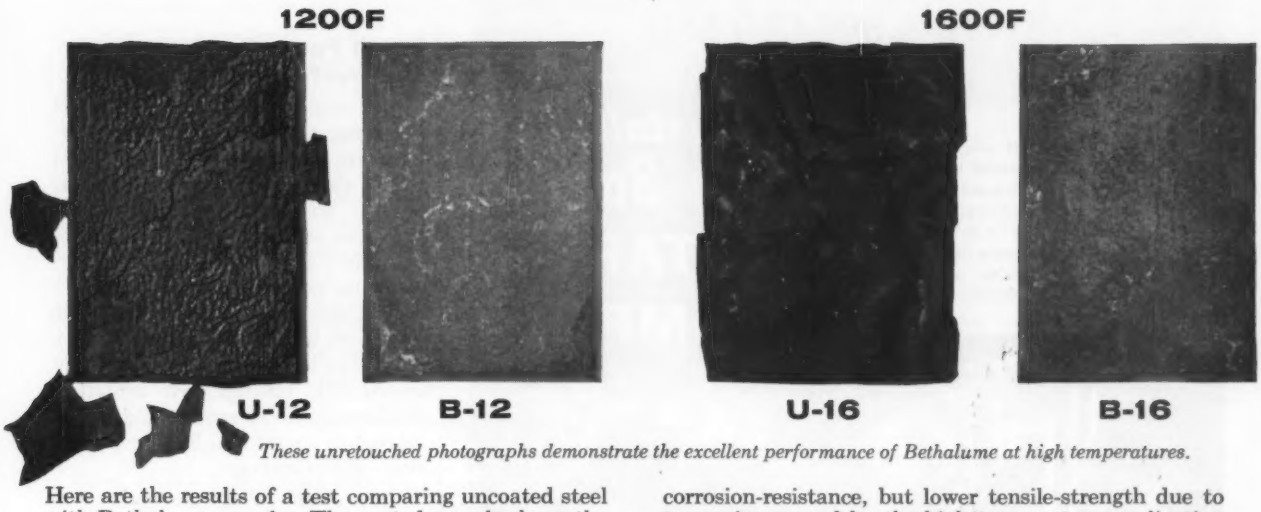
Only the BETHALUME samples survived 1000 hours of intense heat . . . with no loss of weight



These unretouched photographs demonstrate the excellent performance of Bethalume at high temperatures.

Here are the results of a test comparing uncoated steel with Bethalume samples. The coated samples have the same thickness of aluminum coating as is applied to Bethlehem quenched nuts and continuous-thread alloy studs.

All four pieces of C1020 steel, shown above, were exposed to intense heat (1200F and 1600F) for 1000 hours in an oxidizing atmosphere. Samples "U-12" and "U-16" were uncoated. Samples "B-12" and "B-16" have the Bethalume coating.

Here's what happened . . .

"U-12" lost 26.3 pct of its original weight, after scale removal.

"U-16" turned completely to scale in 800 hours.

"B-12" has *gained* 0.12 pct of its original weight (due to the formation of aluminum oxide surface).

"B-16" has *gained* 0.5 pct of its original weight (due to the formation of aluminum oxide surface).

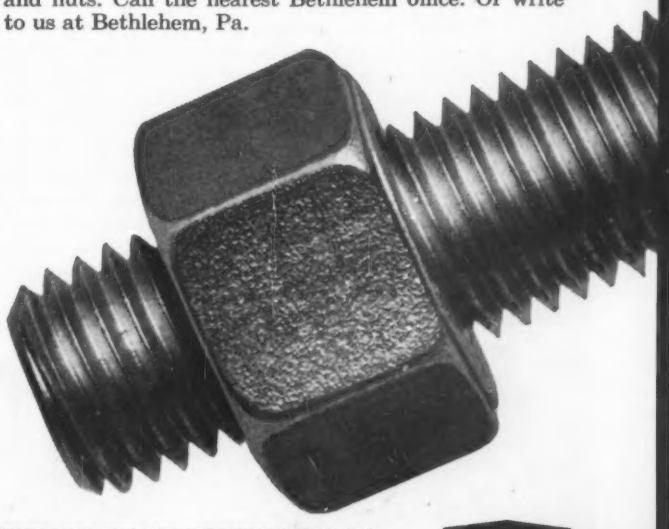
The gain of weight in the Bethalume samples is negligible. Results indicate that Bethalume gives maximum protection against corrosion caused by service at elevated temperatures. And, Bethalume studs and nuts are easily disassembled because their threads are non-galling.

Heat-treatment before or after Bethalume . . .

Bethlehem offers two methods of heat-treating these fasteners—*before* or *after* the Bethalume coating, depending upon the requirements of your particular application. In the former, you get maximum atmospheric corrosion-resistance, but lower tensile-strength due to tempering caused by the high temperature application of Bethalume. When heat-treated *after* coating, the fasteners have lower atmospheric corrosion-resistance values, but will meet all minimum strength requirements. (The high temperature corrosion-resistance of Bethalume studs and nuts, however, is not affected by either procedure.)

Why not run your own test?

Place your order for two or three assemblies (one assembly consists of a stud and two nuts), and install them alongside the connectors you are now using. In this way, you can compare and see for yourself the extended service life available from Bethalume studs and nuts. Call the nearest Bethlehem office. Or write to us at Bethlehem, Pa.



Elevated temperature tests and extended atmospheric corrosion exposures indicate that Bethalume studs and nuts are ideal for use in high-temperature oil refinery bolting.

Steel *for Strength . . . Economy . . . Versatility*

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

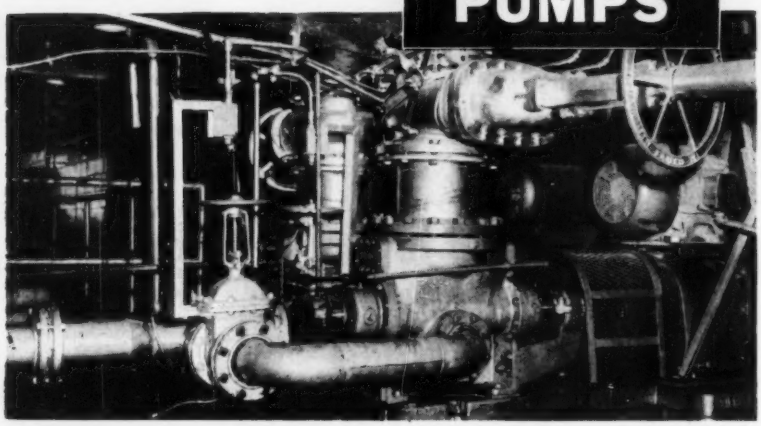
BETHLEHEM STEEL

BETHLEHEM STEEL

When your processes call for
HIGH VISCOSITY PUMPING
UP TO 5,000,000 SSU

EXAMPLE: Shown is one of five Sier-Bath Screw Pumps which have been in steady service 7 to 10 years, pumping 45 gpm. of acid dope having 1,000,000 to 2,000,000 SSU at 122° F. In other plants, Sier-Bath Rotary Pumps are handling adhesives, rubber-resins mixtures and gum bases up to 5,000,000 SSU.

Install
Sier-Bath
ROTARY
PUMPS



Sier-Bath Rotary Pumps are outstanding for pumping heavy, viscous materials such as oils, greases, gums, adhesives, polymers, asphalt, molasses, etc.

Precision rotors, axially positioned by timing gears, move high volumes of high-viscosity materials with smooth, pulseless flow—without strain, misalignment or wear. Heating requirements are lower; operation is quiet, vibration-free. You get continuous pumping for years, with little or no maintenance.

Three lines of Sier-Bath Gear and Screw Pumps meet every requirement in handling viscous lubricating or non-lubricating materials. Wide choice of alloys, bodies, constructions. WRITE for catalogs giving complete descriptions and specifications. See "Yellow Pages" for nearest representative. Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Boulevard, North Bergen, N. J.

Viscosities: 32 to 5,000,000 SSU Volumes: to 2,600 gpm. Pressures: to 1,000 psig.

Sier-Bath ROTARY PUMPS

Screw Pumps Gearex® Pumps Hydrex® Pumps

Founded 1905 Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings Member A.G.M.A.

New Equipment . . .

of control theory, or to provide a background for those seeking only a general knowledge of the analytical approach to control dynamics. Fisher Governor Co.

Circle E20 green card, last page

Small Pump Brochure Has Performance Curves

A compact, close-coupled, fractional horsepower, single-stage-single-suction pump (Model C-15, Type RHK) designed for low-cost handling of clear, non-corrosive liquids at temperatures up to 180° F is described in a new leaflet that includes performance curves and dimensions.

Available in a range through 48 gpm with heads to 100 feet, the new pump can be installed horizontally or vertically. Casings have centerline discharge, are self-venting and can be rotated to any of four 90-degree positions. Allis-Chalmers.

Circle E21 green card, last page

Fine Particles Removed By New Mist Eliminator

Monsanto Chemical Co. has announced that a license has been granted to manufacture and sell the new "packaged" Brink mist eliminators.

These eliminators, a product of Monsanto research, offer a simple economical method for the removal of fine particles (less than three microns in size) from industrial gases at a guaranteed high efficiency, heretofore not done economically. The packaged units are capable of handling up to 900 cubic feet of effluent gases per minute. Continental Mfg. Co.

Circle E22 green card, last page

Soft Packing Resists Mild Acids and Alkali

A "new and different" soft packing, 5555—described by the manufacturer as an ideal packing for solvent and mild acid or mild alkali service—is a plastallic packing featuring a powdered Teflon-asbestos fiber core and a single, non-metallic braided asbestos yarn jacket, thoroughly impregnated with Teflon suspensoid.

A feature of this general service packing is a plastallic core which permits its use as a valve stem ring

"Made OF Stainless Steel ...Made BY Jenkins"

Write the COMPLETE SPEC for an extra-measure of service

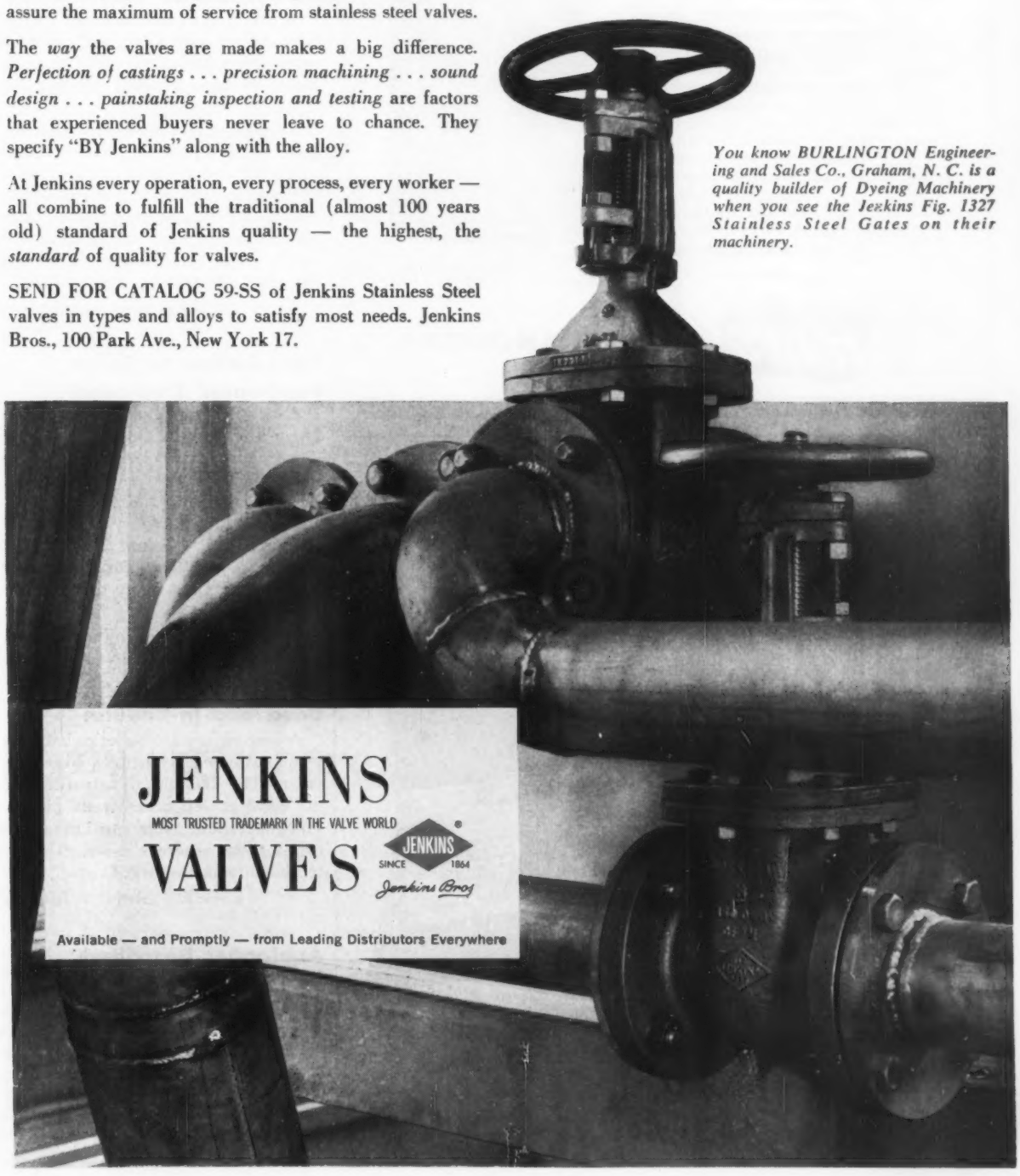
Of course the metal, the alloy, is important when applications require stainless steel valves. But the specification for a suitable alloy is only half the specification needed to assure the maximum of service from stainless steel valves.

The *way* the valves are made makes a big difference. *Perfection of castings . . . precision machining . . . sound design . . . painstaking inspection and testing* are factors that experienced buyers never leave to chance. They specify "BY Jenkins" along with the alloy.

At Jenkins every operation, every process, every worker — all combine to fulfill the traditional (almost 100 years old) standard of Jenkins quality — the highest, the *standard* of quality for valves.

SEND FOR CATALOG 59-SS of Jenkins Stainless Steel valves in types and alloys to satisfy most needs. Jenkins Bros., 100 Park Ave., New York 17.

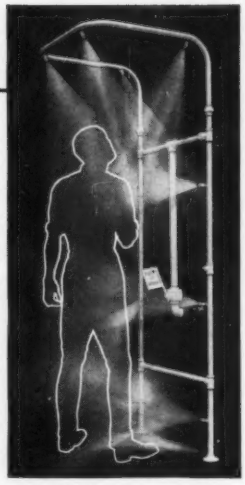
You know BURLINGTON Engineering and Sales Co., Graham, N. C. is a quality builder of Dyeing Machinery when you see the Jenkins Fig. 1327 Stainless Steel Gates on their machinery.



You're all wet . . . AND SAFE!

in a HAWS Emergency Drench Shower.

Burning, corrosive, caustic contamination can inflict injuries more dangerous than blazing clothing! Contamination by acids, chemicals, volatile fuels, radioactive elements, etc., must be instantly countered by *first aid*. Immediate drenching with clear water is the first precaution against permanent injury. HAWS leads in design and production of Emergency Drench Showers! *Ask for our complete catalog.*



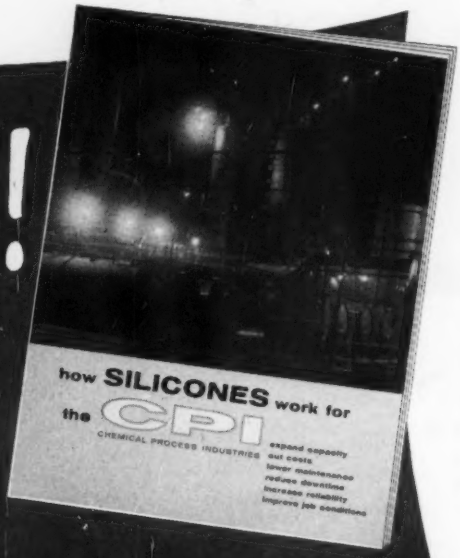
Model 8590
Multiple nozzle shower drenches victim from all angles.

Since 1909 HAWS **DRENCH SHOWERS**

a product of HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, Calif.

Free!

"How SILICONES work for the CPI"



New manual describes how silicones expand capacity and reduce costs in all phases of the process industries. Send today for your free copy. Write Dept. 9823.

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MIDLAND, MICHIGAN

New Equipment . . .

where out-of-square sizes are required.

The packing is offered in sizes of one-eighth through one inch in 1/16-inch increments. Garlock, Inc.

Circle E23 green card, last page

Bulletin Outlines Control Of Distillation Columns

A new application bulletin, "Distillation Column Controls," outlines typical practices for control of distillation columns in hydrocarbon processing.

Typical instrumentation of the feed, bottoms product, reboiler circuit and overhead product phases of distillation is covered in the eight-page bulletin. Pertinent instrument loops are illustrated and the instruments which form these loops are briefly described. Fischer & Porter Co.

Circle E24 green card, last page

Introduction to Boiler Feedwater Treatment

A new 24-page booklet titled "An Introduction to Boiler Feedwater Treatment" answers some questions like: "How Pure Must Feedwater Be?" "How Does Operating Pressure Influence Boiler Water Composition Requirements?" "What is Meant by 'External' and 'Internal' Feedwater Treatment?" and many more. Nalco Chemical Co.

Circle E25 green card, last page

Knife-Type Gate Valve Described in Bulletin

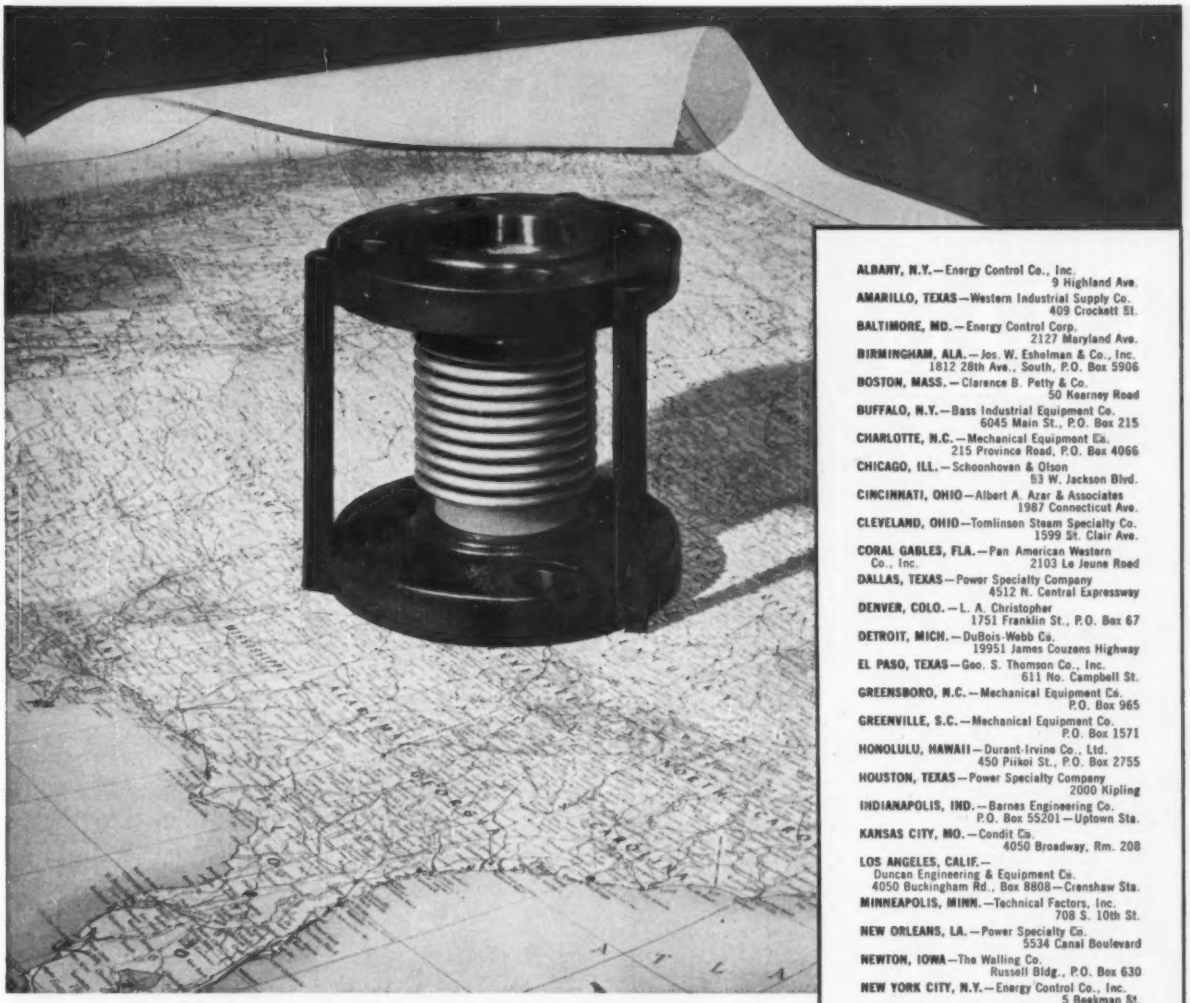
A new eight-page bulletin describes a rubber-seated, bonnetless, knife gate valve. The bulletin lists features of the valve as well as materials, dimensions, actuators, and outlines the broad areas where the valve is extensively used. DeZurik Corp.

Circle E26 green card, last page

Analogger Described In 8-Page Bulletin

A new, eight-page publication describing the MP-12 analogger includes design data and operating benefits. Also provided is information on optional recording receivers and integrators for use with the analogger. Republic Flow Meters Co.

Circle E27 green card, last page



These 48 Sola-Flex® representatives can serve you anywhere...faster!

WHEREVER YOU ARE LOCATED in the United States there is a dependable Sola-Flex representative nearby—ready to give immediate service and technical assistance on your expansion joint needs. This prompt, efficient service is but one of the many reasons why forty of America's fifty largest businesses rely on Sola-Flex expansion joints to help solve difficult piping problems. (Another reason is the outstanding Sola-Flex record of performance and reliability.)

Solar manufactures the most comprehensive line of expansion joints in the world. They are made from a wide variety of stainless and high-temperature alloys in a complete range of sizes from ½ in. to 35 ft in diameter. Temperatures range from −320F to 1200F, pressures from full vacuum to 600 psi and up. And rugged Sola-Flex expansion joints can be "in service" one to four weeks after receipt of order.

An illustrated pamphlet describes Solar's complete line of Sola-Flex expansion joints. Write for it to Dept. J-171, Solar, San Diego 12, California.

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For more data on advertised products, use cards, last page.

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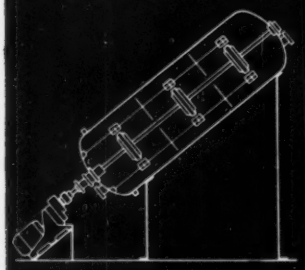

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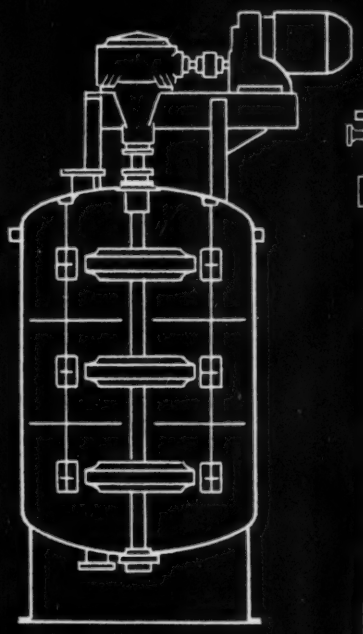

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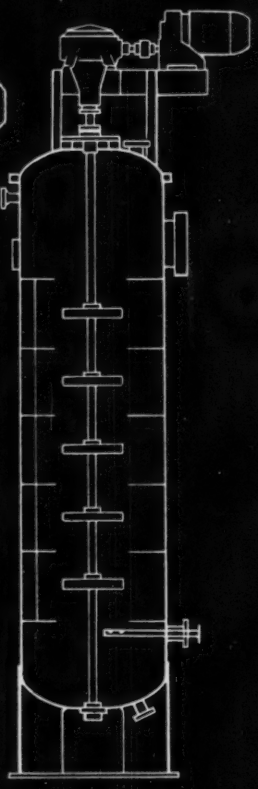

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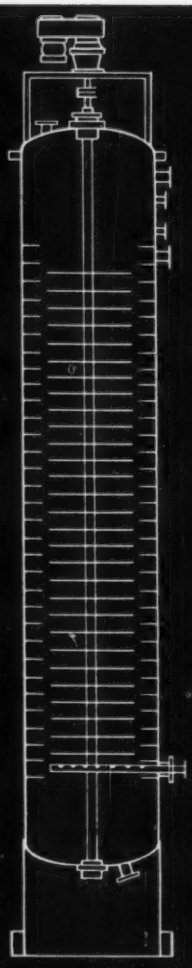

4

1 First staged mixer (1933) supplied to industry. Designed and built by Turbo-Mixer.

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3 Concurrent or countercurrent Turbo-Mixer reactor built in any size or number of stages.

4 RBC* column built by Turbo-Mixer. Latest word for countercurrent extraction.

STILL 1st WITH THE BEST

Staged mixing equipment is an old and continued story with Turbo-Mixer. From the first staged mixer, patented in 1933, through constantly improved concurrent and countercurrent equipment to the Rotating Disc Contactor, the staged mixing and extraction equipment preferred in most industries, General American's Turbo-Mixer Division has led the way. You may be sure General American research and industrial knowhow will maintain this leadership.

Write for Bulletins #T-11 and #T-1159 for descriptive details!

Process Equipment Division—Turbo-Mixers

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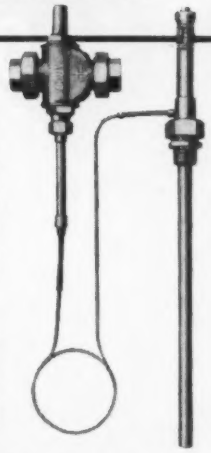
TURBO-MIXER GENERAL AMERICAN TRADE MARK

Offices in principal cities

*Patented

SARCO self-powered TEMPERATURE REGULATOR

TYPE 50-21



Fully Modulating. Because the Sarco 50-21 does not depend on external power such as electricity or compressed air, it has established long records for sustained, dependable operation. Sensitive liquid filled thermal system provides uniform valve movement for degree of temperature change.

Features: Valve sizes ½" to 2". Can be calibrated for 50 or 100° temperature range between 0 and 230°F. Pressures to 175 PSIG. Packless valves. No exposed mechanism.

Use the 50-21 for: hot water tanks, condensers, compressors, shell-and-tube heat exchangers, etc. Bulletin 620 gives full details.

7308

SARCO

SARCO COMPANY, INC.
635 MADISON AVE., NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

SPLIT-EYELET CONNECTORS

For faster, easier connection of spray nozzles, branch lines and equipment to piping and tubing carrying liquids, gases or air up to 250 psi. Write for Bulletin 93.

FOR BETTER PERFORMANCE

SPRAY NOZZLE ACCESSORIES

ADJUSTABLE JOINTS

For easy, exact adjustment of spray direction. Made in size for ¼" to 2½" pipe in brass, steel and stainless steel. Write for Bulletin 97.

. . . EASIER INSTALLATION

FOR COMPLETE SPRAY NOZZLE INFORMATION WRITE FOR CATALOG 24

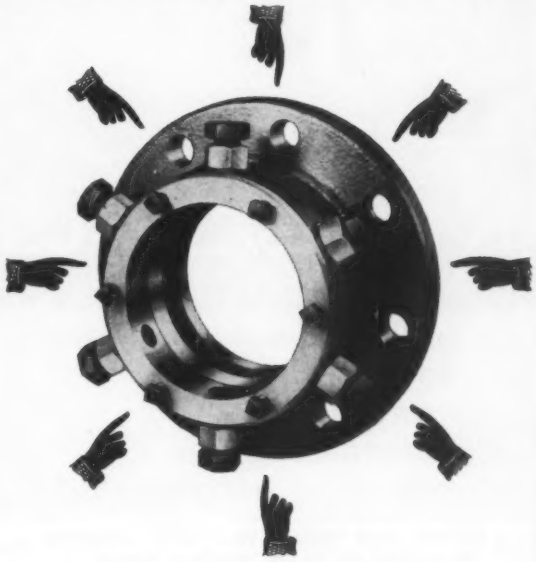
LINE STRAINERS

Special non-collapsing screen design for pressures up to 125 psi, for all pipe lines from ¼" to 6" size. Also high pressure strainers for up to 5,000 psi service. Write for Bulletin 94.

SPRAYING SYSTEMS CO.
3283 RANDOLPH STREET • BELLWOOD, ILL.

PLIDCOFLANGE
PLIDCOFLANGE
PLIDCOFLANGE

. . . NO OTHER PIPE FITTING DOES SO MANY JOBS SO WELL



Designed for fast, easy installation plus economy

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Plidcoflange slips over end of pipe, mates up with standard flange facings. No flange spreaders, jacks or bars required. Ideal for use as a blind plate flange. Just slide Plidcoflange back to change plates.

Plidcoflanges are available in standard sizes 2" through 12" with 150 lb. A.S.A. steel flanges. Other sizes and pressure classes on request. Send for illustrated brochure.

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REPRESENTATIVES THROUGHOUT THE WORLD
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NOW PORTABILITY plus ACCURACY and up to

50% SAVINGS IN COST!

ALL the advantages of a conventional multi-rack data system in one PORTABLE package!

MOBIDAC

MOBILE DATA ACQUISITION SYSTEM

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- √ **STRAINS**
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- **CONNECT YOUR TRANSDUCERS DIRECTLY** to MOBIDAC. No external d-c channel amplifiers required.
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CONDENSED SPECIFICATIONS

Data Channels 48
Input Levels ± 4 millivolts to ± 4 volts
Accuracy (full scale) 0.1%
Sampling Programs Selectable by front panel switch
Sampling Rate Up to 3000 sps
Display Decimal display for individual channel data

Output Format Gapped or gapless for all major computers
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Size.....36" x 20" x 24"
Weight .....175 pounds
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90 DAY DELIVERY

OPTIONS: Increased channel capacity . . . 100 or more, Higher Sampling Speeds, Quick-Look Display, Punched Tape and Card Outputs.

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Rockwood Unions' Exclusive Features Even Include the Way They're Shipped!

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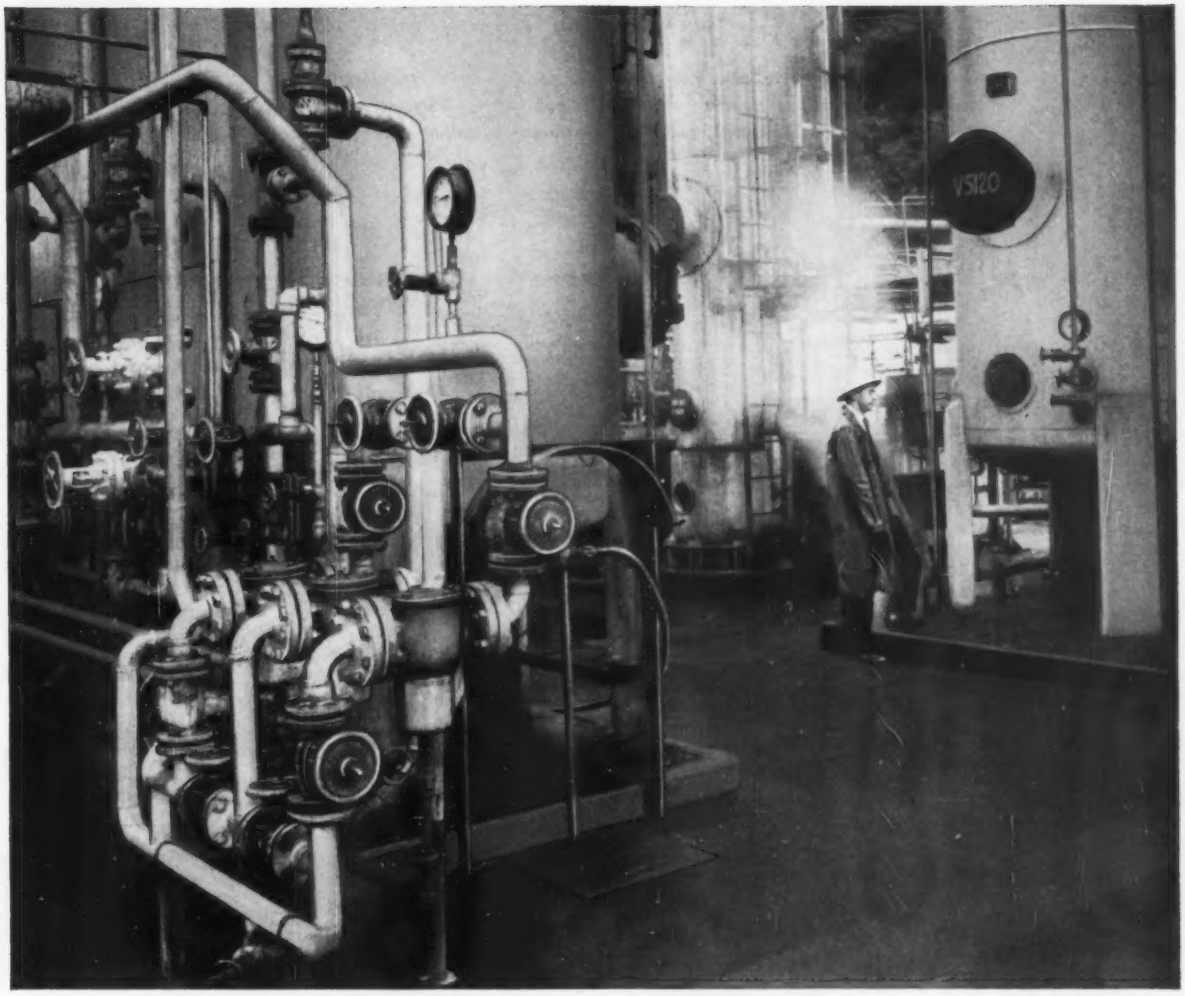
You note the difference the first time you handle Rockwood Unions. They're *boxed*, with their contents clearly labelled and identified. They're easier to handle, easier to store and use. But that's only the beginning! *Only* Rockwood Unions have the hardness differential that assures fast, easy make-up, tight seal and freedom from galling! *Only* Rockwood offers four different seat types. *Only* tough Rockwood Unions give you complete corrosion protection including "Rockwoodizing," the process that makes the threads and the entire surface of the union corrosion resistant. Longer lived, vibration and shock resistant Rockwood Unions are available in a wide range of sizes . . . all parts are interchangeable. Regardless of your needs, Rockwood Unions will do a better job for you. For complete facts write Rockwood Sprinkler Company, Union Department, 725 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Co., A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD UNIONS



Grinnell-Saunders Diaphragm Valves on sweetening towers handle gasoline, stove oil at 70-80 psi.

Corrosion-resistant Grinnell-Saunders Diaphragm Valves pass 6-year milestone at Standard Oil of British Columbia

Conventional valves subject to frequent, costly replacement

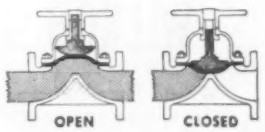
Standard Oil Company of British Columbia Limited had a tough problem on the sweetening towers at their Burnaby refinery. Some of the 11-13% chrome trim, cast steel gate valves on the tower connections kept corroding badly — several even had to be replaced every 3 months. Result: high valve replacement costs!

To solve this problem, Standard Oil replaced these valves with cast steel, plastic-lined Grinnell-Saunders Diaphragm Valves. That was 6 years ago!

Today, the Grinnell-Saunders Valves are still on the job — still operating easily, still closing tightly.

Here's why Grinnell-Saunders Valves can give this kind of service. Operating mechanism is completely isolated from the fluid stream by the diaphragm to prevent corrosion. There are no pockets, no rough edges to trap particles that can corrode the valves. Plastic linings and neoprene diaphragms resist attack by water, hydrochloric acid, hydrocarbon and copper chloride present in the gasoline and stove oil that go through the valves.

If you have severe valve problems, there are Grinnell-Saunders Diaphragm Valves to solve them. Wide selection of body materials, linings, diaphragm materials.



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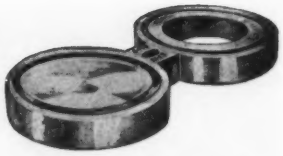

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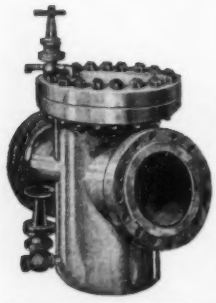

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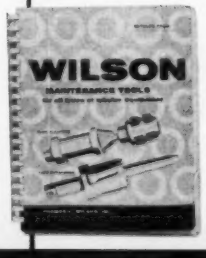

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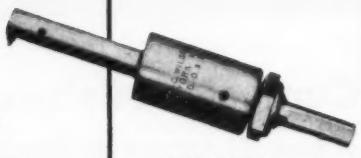

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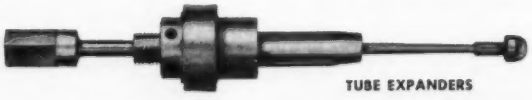
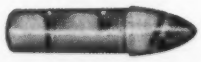


TUBE EXPANDERS



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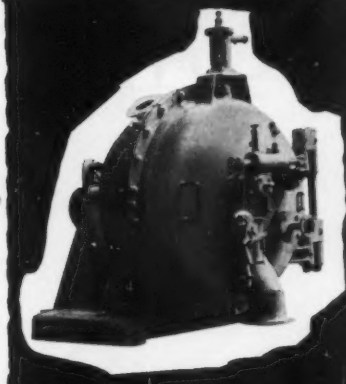
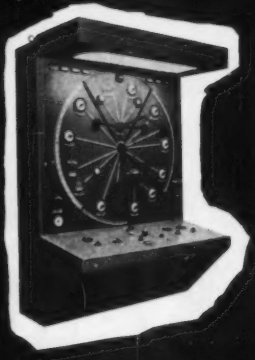
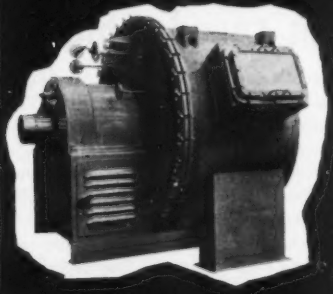


Electrical control



Pressure-tight filter



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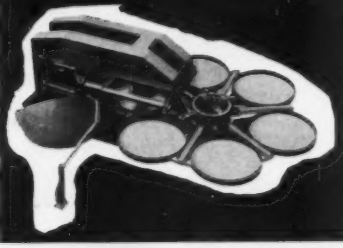

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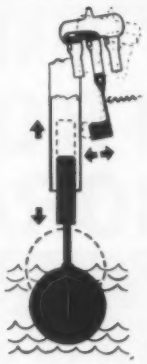

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☐ Liquid Level Controls ☐ Flow Controls

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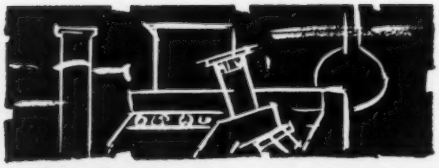

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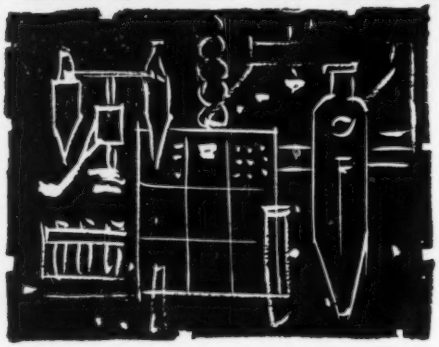

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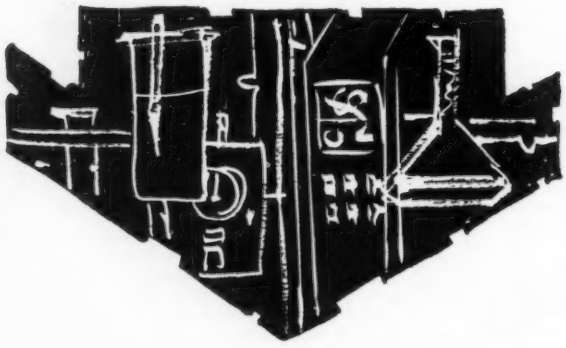

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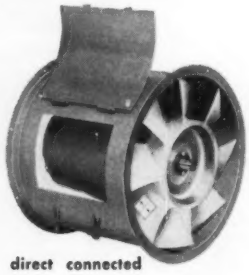

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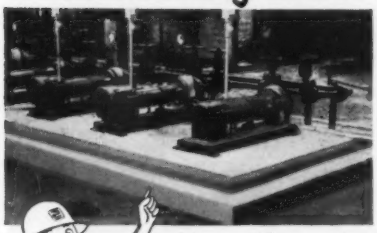

against acid corrosion

Wherever acid spills or leaks, as on these pump bases, or where acids attack quench towers, you'll find Sauereisen No. 54 Acid-Proof Concrete providing permanent protection against corrosion, at temperatures to 2000° F. Can be poured into forms or applied as a topping.

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SAUEREISEN
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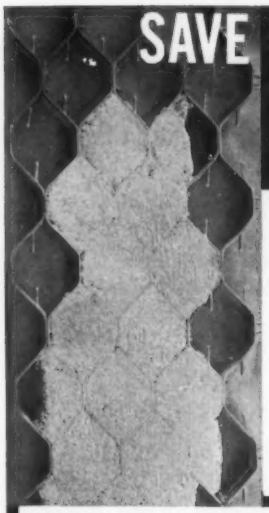

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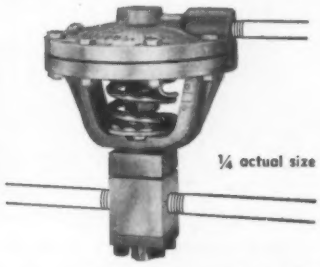

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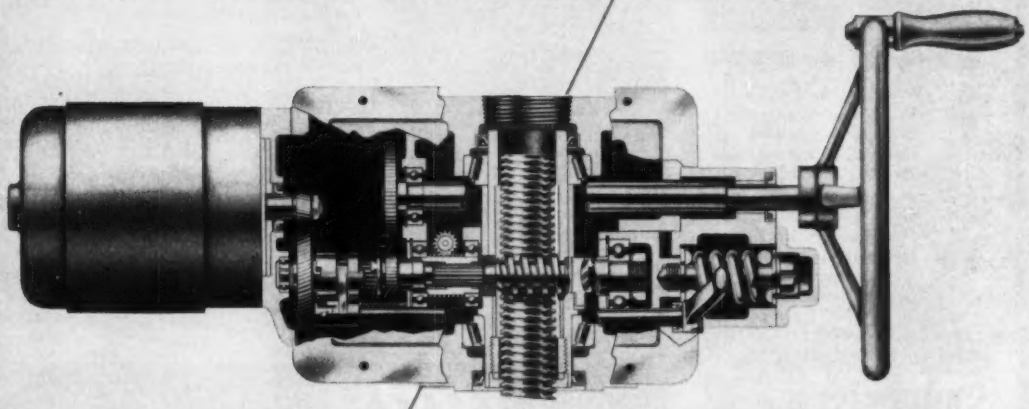

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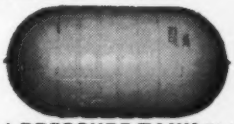

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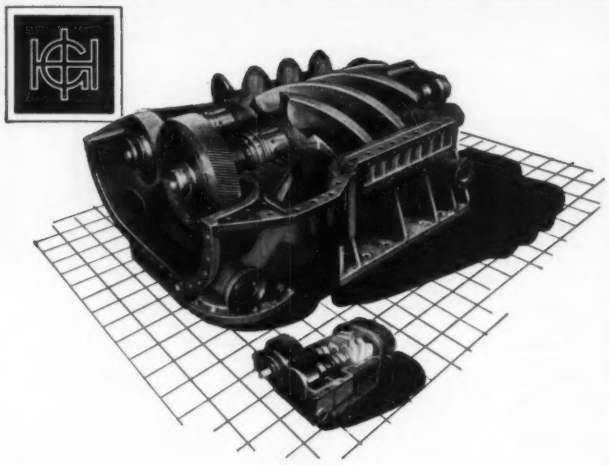

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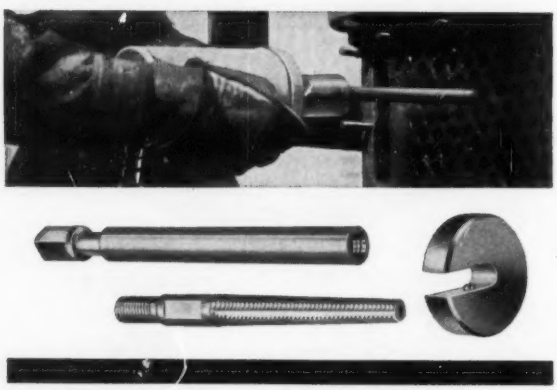

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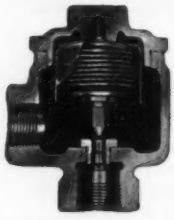

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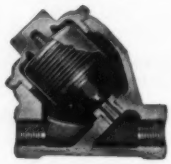

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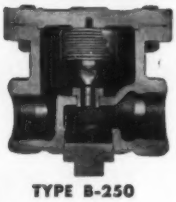

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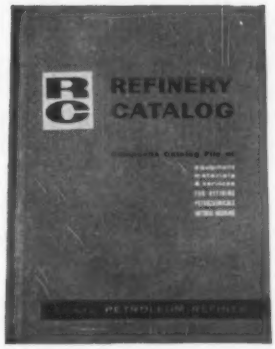

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A

*A. P. V.-Paramount Ltd. 36L
Aerofin Corp. 94
*Aerovent Fan Co.
Large Propeller Division 464b
*The Air Preheater Corp. 450
*Airetool Manufacturing Co. 415
W. G. Allen & Sons (Tipton) Ltd. 36Xb
Alley Compressors Ltd. 36Wb
Allied Chemical Corp.
General Chemical Division 40
Allied Chemical Corp.
Nitrogen Division 42
Allied Chemical Corp.
Solvay Process Division 426
Alloy Steel Products Co. 341
*Aluminum Company of America 403
Amercoat Corp. 122
American Air Filter Co. 114
American Brake Shoe Co. 104
American Cyanamid Co.
Refinery Chemicals Dept. 115
American Meter Co.
Pump Division 77
American Pipe and Construction Co. 147
American Steel & Wire Division
United States Steel 160-161
The Annin Co. 359
*The Anthes-Imperial Co. 36V
Anthracite Equipment Corp. 447b
*Armstrong Machine Works 372
*Associated Electrical Industries Export Ltd. 36S
Associated Electrical Industries Ltd. 36A, 36II
Automatic Control Engineering Ltd. 361
Avondale Shipyards, Inc. 116-117

B

B-I-F Industries, Inc. 102-103
Babbitt Steam Specialty Co. 469a
*The Babcock & Wilcox Co. 120-121
The Babcock & Wilcox Co.
Tubular Products Division 11
Badger Manufacturing Co. 128-129
*Bailey Meter Co. 188
*Baldwin-Ehret-Hill, Inc. 364
Barco Manufacturing Co. 416
Barksdale Valves 176
Barton Instrument Corp. 410
Beckman Instruments, Inc. 59, 61
The Bendix Corp.
Bendix Computer Division 440
Hch. Bertrams AG 36G-36GG
Bethlehem Steel Co. 453
Betz Laboratories, Inc. 78-79
*Black, Sivalls & Bryson, Inc. 405
*Blackmer Pump Co. 447a
Bonney Forge & Tool Works 399
*Brazil Tool & Die Shop 469c
The Bristol Co. 132-133
British Ermeto Corp. Ltd. 36H
British LaBour Pump Co. Ltd. 36F
Brown & Root, Inc. 355
*Brown Fintube Co. 96
*Buell Engineering Co. 8
*Buffalo-Eclipse Corp. 407
Bufnel Company
Division Smith Industries
International, Inc. 465c
Burnett & Rolfe Ltd. 362a
Burrell Corp. 418

C

*Calumet & Hecla, Inc. 145-146, 423
*Camco Fittings, Inc. 404
*Cameron Iron Works, Inc. 173
*Cape Insulation and Asbestos Products Ltd. 82
*Capitol Pipe & Steel Products, Inc. 202
*The Philip Carey Mfg. Co. 136-137
*G. O. Carlson, Inc. 100
Carter-Waters Corp. 452b
Catalytic Combustion Corp. 36
Catalytic Construction Co. 66
Celanese Chemical Co.
Division Celanese Corporation
of America 168-169
Central Soya
Chemurgy Division 342
*Chemical Construction Corp. 34
Chemical Industries Exposition 434
*Chicago Pneumatic 150-151
*Chiksan Co. 171
Chiyoda Chemical Engr. & Const. Co. Ltd. 37
Classified Advertising 470
*Clayton Mark & Co. 367
Cockburns Limited 36u
Columbia-Geneva Steel Division
United States Steel 425
Conax Corp. 365
*The Cooper-Bessemer Corp. 54-55
*Coppus Engineering Corp. 187
Crane Co. 84, 360
Crane Packing Co. 413
W. H. Curtin & Co. 464a

D

George W. Dahl Co. 465d
Darling Valve & Mfg. Co. 20
*Davis Instruments Division
Davis Emergency Equipment Co. 371b
Davison Chemical Division
W. R. Grace & Co. 2
*Degussa Hanau 36Xa
De Laval Steam Turbine Co. 396
Deloro Stellite Ltd. 36EE
Dempster Brothers, Inc. 4
Desco Engineering Corp. 469b
Diamond Electronics Division
Diamond Power Specialty Corp. 392-393
Didier-Werke AG 36B
Don Supply Co. 469d
Dow Corning Corp. 456b
Dow Industrial Service Division
The Dow Chemical Co. 383
*Dresser Industries, Inc. 27
Drott Manufacturing Corp. 143
*The Ducon Co. 172
E. I. du Pont de
Nemours & Co. 165, 166, 167, 429-430
*Duraloy Co. 441
Durametallic Corp. 198

E

The Eagle-Picher Co. 330
Eastman Chemical Products, Inc. 63
Electro-Alloys Division
American Brake Shoe Co. 104
*Elliott Co. 154
*Engineers & Fabricators, Inc. 358
Ethyl Corp. 38, 325
Exomet Inc. 442

F

Fairbanks, Morse & Co. 30-31
Farris Engineering Corp. 424
Fisher Governor Co. 185, 345
Flexonics Division
Calumet & Hecla, Inc. 423
*Flint Steel Corp. 362
*Food Machinery & Chemical Corp. 119, 126
The Foram Corp. 468a
Benjamin Foster Co. 390, 391
*Foster Wheeler Corp. 24-25
The Foxboro Co. 158-159, 398
Fram Corp. 68

G

*The Gamewell Co. 144, 460b
Gardner-Denver Co. 374
*Garlock Inc. 388
*Gas Atmospheres, Inc. 444
General American Transportation Corp. 458
General Chemical Division
Allied Chemical Corp. 40
General Electric Co. 48-49
A. J. Gerrard & Co. 197a
Gilbert & Barker Mfg. Co. 446
Girdler Corp. 353
Glascote Products, Inc. 336-337
*Fritz W. Glitsch & Sons, Inc. 182
*Claud S. Gordon Co. 451a
*Goulds Pumps, Inc. 95
W. R. Grace & Co. 2
*Graham Manufacturing Co. 181
*Grinnell Co. 461
*The Griscom-Russell Co. 127
Groban Supply Co. 467a
Grove Valve & Regulator Co. 80
Gutehoffnungshuette 468a

H

Hagan Chemicals & Controls, Inc. 44
Hamilton Co. 467c
W. A. Hammond Drierite Co. 465b
*Harbison-Walker Refractories Co. 375-378
*The Harshaw Chemical Co. 14
*Hartzell Propeller Fan Co. 373
Hawker Siddeley Engineering 36E
Haws Drinking Faucet Co. 456a
C. I. Hayes, Inc. 340
*Head Wrightson Processes Ltd. 36CC
*Heliflow Corp. 181
Hercules Powder Co. 371a
*Hoke, Inc. 85
*Houdaille Industries, Inc. 448
Houdry Process Corp. 140-141
Houston Engineering & Mfg. Co. 467b
*Hudson Engineering Corp. 417
Humble Oil & Refining Co. 29
Huntington Alloy Products Division
The International Nickel Co. 67
Hupp Aviation Division
Hupp Corp. 466
*Hydril Co. 370
Hydromatics, Inc. 179-180

I

IBM Corporation 162-163
ISI, Incorporated 198
Imperial Chemical Industries Ltd. 36C
Imperial-Eastman Co. 384, 385
Inert Gas Inc. 386
*Ingersoll-Rand Co. 92-93
International Harvester Co. 457
The International Nickel Co. 67, 339

J

*Jamesbury Corp. 60
Jenkins Bros. 455
*Jerguson Gage & Valve Co. 431b
*Johns-Manville Corp. 186, 394-395

K

Kaiser Refractories 397
*Keasbey & Mattison Co. 28
The M. W. Kellogg Co. 12, 199, 368-369
Ernst Kirchner 36Wa
*Klein, Schanzlin & Becker AG 46
Klockner-Humboldt-Deutz AG 36DD
*Koch Engineering Co. 475
Krauss-Maffei-Imperial 463a
*Krueger Engineering & Mfg. Co. 366
Fried. Krupp Maschinenfabriken 36LL

L

Langley Alloys Ltd. 36NN
*Lapp Insulator Co. 343
Layne and Bowler, Inc. 155
Leeds & Northrup Co. 26
Warner Lewis Co.
Division Fram Corp. 68
LimiTorque Corp. 142
Linde Co.
Division Union Carbide Corp. 400, 401
Gesellschaft fur LINDE'S
Eismaschinen AG 62
*The Lummus Co. 118, 319
The Lummus Co., Ltd. 36Y

M

M. A. N. Maschinenfabrig Augsburg 435
*The Mack Iron Works Co. 462a
*Magnetrol, Inc. 463b
*Mannesmann-Export 36KK
Manning, Maxwell & Moore, Inc. 22, 87
*Manzel Division
Houdaille Industries, Inc. 448
*Mason-Neilan Division
Worthington Corp. 138-139
The Matheson Co. 197b
Arthur G. McKee & Co. 414
Mechans Limited 36M
*The Mercoid Corp. 422b
Metaducts Limited 443
Metal Hydrides, Inc. 113
Metal Propellers Ltd. 362b
Michigan Alkali Division
Wyandotte Chemicals Corp. 432
*Midwest Piping
Division of Crane Co. 84
*Millspaugh Limited 36N
Mineral Products Division
Food Machinery & Chemical Corp. 119
Minneapolis-Honeywell 174-175, 192
Mission Valve & Pump Co. 184
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National Lead Co. 23
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United States Steel 425
*Nettco Corp. 81
Neue Argus Gesellschaft M.B.H. 36R
Newalls Insulation Co. Ltd. 52
*W. H. Nicholson & Co. 428
Nitrogen Division
Allied Chemical Corp. 42
*The C. W. Nofsinger Co. 445
*Nooter Corp. 351

O

Oakite Products, Inc. 411
The Ohio Injector Co. 153
Orbit Valve Co. 164
*Samuel Osborn & Co. Ltd. 36MM
Owens-Corning Fiberglas Corp. 32

P

*Pacific Pumps, Inc.
A Division of Dresser Industries, Inc. 27
Pall Corp. 467d
Panellit Division
ISI, Inc. 193
Parkersburg
Division of Parkersburg-Aetna Corp. 53
The Ralph M. Parsons Co. 91
*Peerless Pump
Hydrodynamics Division
Food Machinery & Chemical Corp. 126
*Penberthy Injector Ltd. 36V
*Penberthy Manufacturing Co.
Division Buffalo-Eclipse Corp. 407
S. B. Penick & Co. 472
Pennsalt Chemicals Corp. 135
Permutit Division
Pfaudler Permutit Inc. 130
Petro-Tex Chemical Corp. 47
*Pfaudler Permutit Inc. 420-421
*Phelps Dodge Copper Products Corp. 18-19
Phelps Dodge Refining Corp. 402
Philadelphia Gear Corp. 142
*Phoenix-Rheinrohr AG 51
Wm. S. Pine, Inc. 468b
Pipe Fabrication Institute 134
*The Pipe Line Development Co. 459c
*Pittsburgh-Des Moines Steel Co. 183
Plibrico Co. 352
Horace T. Potts Co. 436
The Wm. Powell Co. 98-99
Precision Scientific Development 389
Procon Incorporated 83
The Protectoseal Co. 452a
Pulsation Controls Corp. 431a
The Pyrene Company Ltd. 36P

Q

The Quaker Oats Co. 50

R

Raybestos-Manhattan, Inc. 406, 409
*Refinery Catalog 64-65
*Republic Steel Corp. 124-125
Richardson, Westgarth & Co. Ltd. 36T
The Ridge Tool Co. 447c
Frank D. Riggio Co. 468c
Rockwell Manufacturing Co. 105-112
*Rockwood Sprinkler Co.
Division The Gamewell Co. 144, 460b
*Rome Cable Division of Alcoa 419
Rotron Controls
Division Rotron Manufacturing Co. 437a
*The Ruberoid Co. 97

S

SADI 422a
Sarco Co. 148, 459a
Sauereisen Cements Co. 465a
*Scovill Manufacturing Co. 189
*Selas Corporation of America 170
Shell Oil Co. 190
*Sier-Bath Gear & Pump Co. 454
Sivyer Steel Casting Co. 73
*M. B. Skinner Co. 379
A. O. Smith Corp. 336-337
Smith Industries International, Inc. 465c
*Smithco Enginering Inc. 356
Solar
Division International Harvester Co. 457
Solvay Process Division
Allied Chemical Corp. 426
Speedline Fittings Division
Horace T. Potts Co. 436
Spiro-Gills Limited 36BB
Spraying Systems Co. 459b
Square D Company 363
Standard Oil Co. (New Jersey) 58
Stauffer Chemical Co. 439
The Stearns-Roger Mfg. Co. 349
Stockham Valves and Fittings 196
Stone & Webster Engineering Corp. 387
*Strahman Valves, Inc. 451b
*Stratford Engineering Corp. 101
*Sun Shipbuilding & Dry Dock Co. 433
Superior Air Products Co. 35
Swepco Tube Corp. 157
Systems Engineering Laboratories, Inc. 460a

T

The Tapecoat Co. 437b
Taylor Instrument Companies 380-381
*Technical Oil Tool Corp. 344
*The Terry Steam Turbine Co. 156
*Thermal Research & Engr. Corp. 361
The Timken Roller Bearing Co. 191
The Trane Co. 195
*Tretolite Co.
Division Petrolite Corp. 346-347
Tubular Products Division
The Babcock & Wilcox Co. 11

U

Friedrich Uhde GmbH 36Q
Union Carbide Corp. 400, 401
United States Steel Corp. 69-72, 160-161, 425, 449
United States Steel Export Co. 425
U. S. Steel Products Division
United States Steel 69-72
United States Steel Supply Division
United States Steel 425
*United States Stoneware Co. 131
*Universal Atlas Cement Division
United States Steel 449
Universal Oil Products Co. 56-57, 194

V

Varec, Inc. 16-17
*Henry Vogt Machine Co. 33
*J. H. H. Voss Co. 438b

W

James Walker & Co. Ltd. 36D
Walworth Co. 74-75
Warren Petroleum Corp. 320
G. & J. Weir Limited
(Pacific Pumps) 36K
Weir-Pacific Valves Ltd. 36FF
*Well Equipment Mfg. Corp. 382
Wellington Tube Works Ltd. 36HH
West End Chemical Co. 439
Western Supply Co. 6, 470
C. H. Wheeler Mfg. Co. 127
*White Diesel Engine Division
The White Motor Co. 149
Wickes Boiler Co. 86
*The Gustav Wiedeke Co. 438a
A. R. Wilfley & Sons, Inc. 76
*Thomas C. Wilson, Inc. 462b
*Wolverine Tube Division
Calumet & Hecla, Inc. 145-146
*Worthington Corp. 21, 138-139
Wright Chemical Corp. 354
Wyandotte Chemicals Corp.
Michigan Alkali Division 432
Wyatt Industries, Inc. 476

Y

*Yarnall-Waring Co. 152
*Otto H. York Co. 200

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*Zallea Brothers 177

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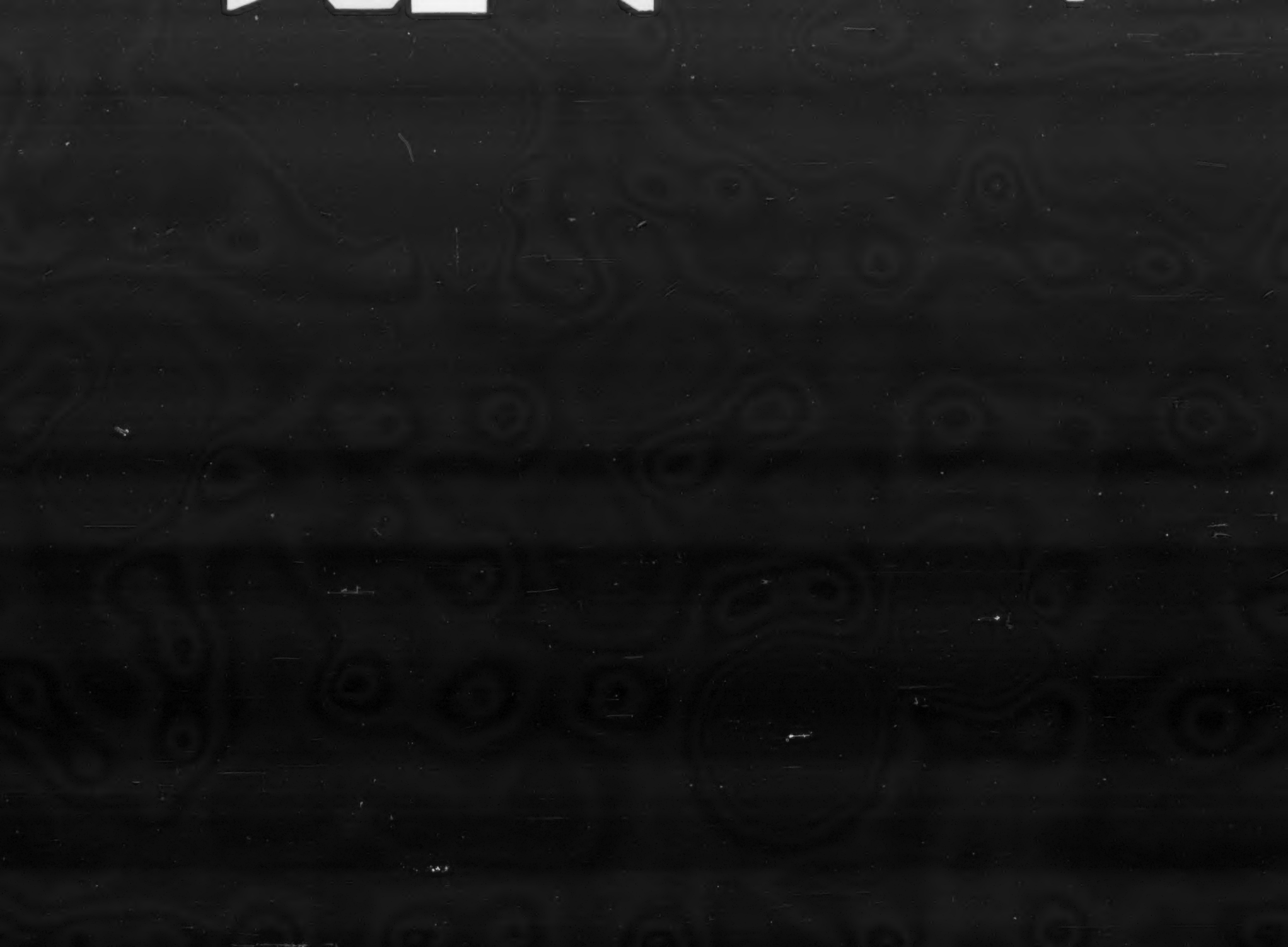
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